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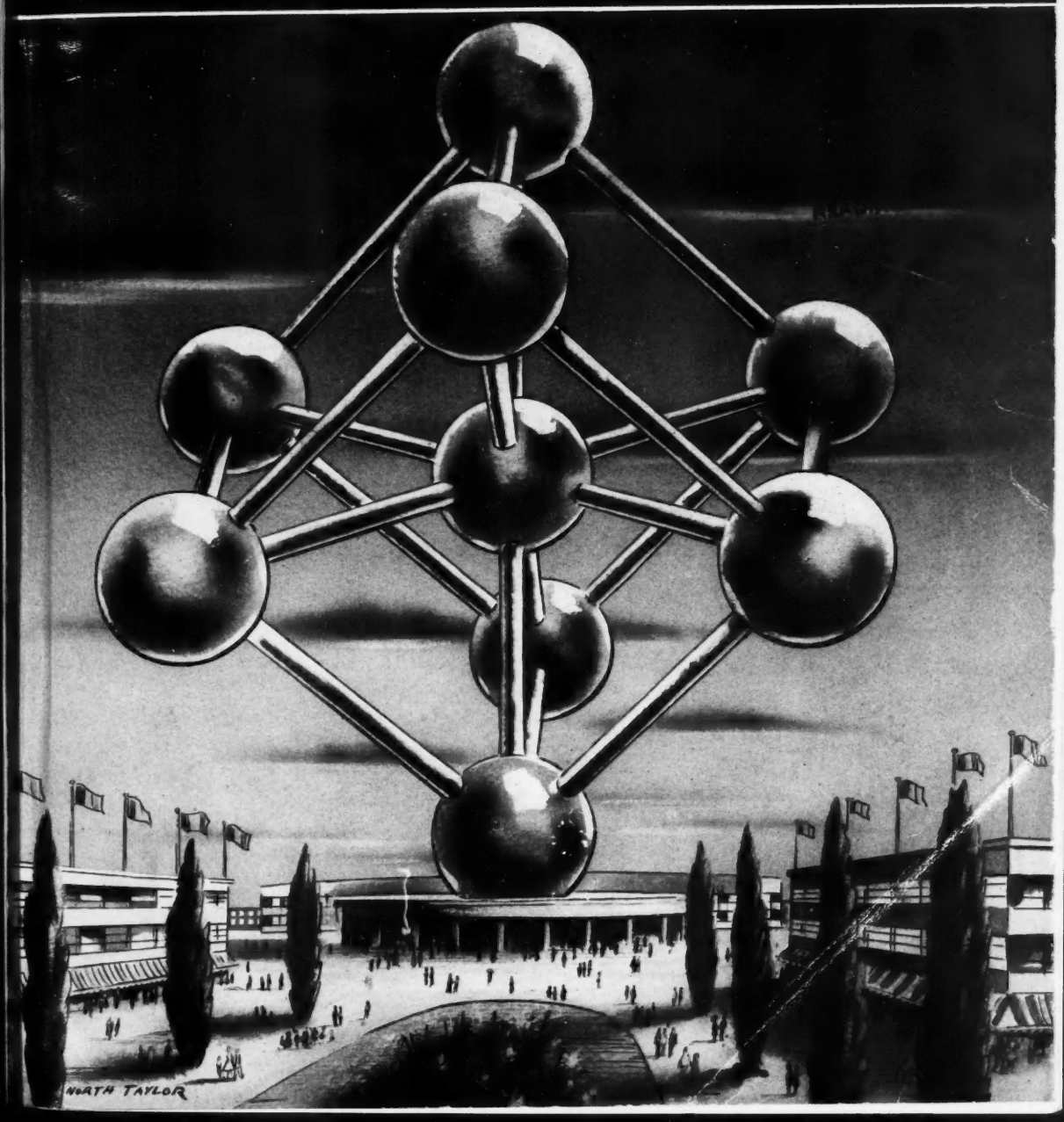

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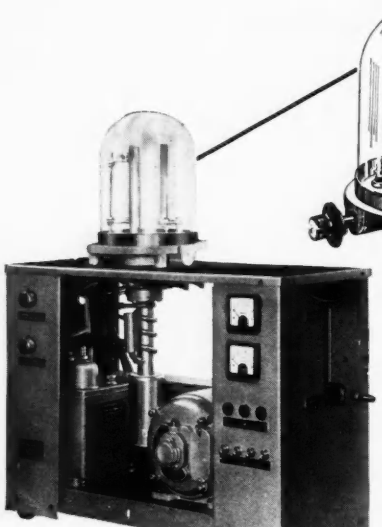

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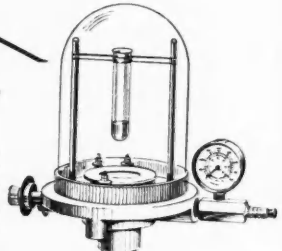

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COVER PICTURE: Great exhibitions like to have large landmarks. The Eiffel Tower was specially built in 1889 for the Paris Exhibition of that year, the Dome of Discovery graced the Festival of Britain in 1951, and the Atomium will be erected in Brussels in 1958 for the Universal and International Exhibition. The Atomium is unique in being a symbolic structure representing an elementary steel crystal; it is planned to reach a height of 360 feet. Each atom of the crystal will be a steel sphere, 70 feet in diameter, containing exhibition halls, stands, and refreshment rooms. Escalators are to join the spheres to make a circular tour of them easy and convenient.

Special colour pages, beginning with this issue, will appear from time to time in DISCOVERY.

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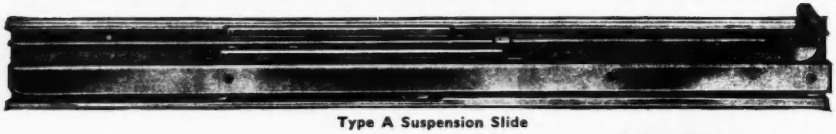

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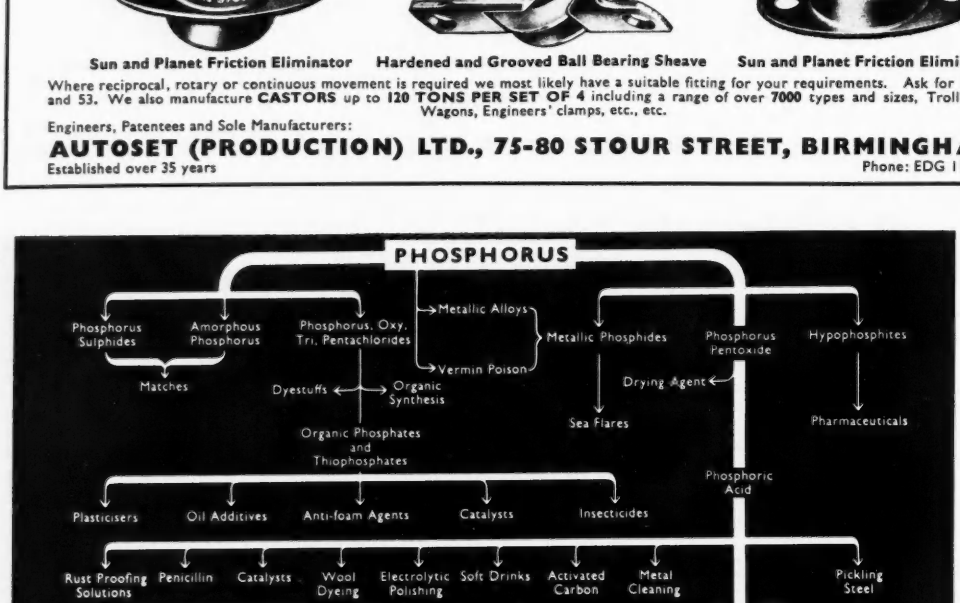

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THE PROGRESS OF SCIENCE

THERMONUCLEAR ENERGY

It was certainly a most unusual and unexpected occasion when the Senior Executive of the Russian Atomic Energy Organisation offered to give a scientific lecture at Harwell on the subject of thermonuclear power. Though it is known that considerable attention is being paid to the subject both at Harwell and in the U.S.A., it is a topic which was excluded from technical discussion at the Geneva Atomic Energy Conference, and it is more or less in the classified category. The text of the lecture, issued in printed form afterwards, describes in the manner of a careful scientific report, some fundamental experiments on the most obvious way of trying to obtain a thermonuclear reaction: namely, the passage of a very intense pulsed current (lasting several microseconds) of the order of a quarter of a million amperes obtained by the discharge of a large condenser bank, in a linear discharge tube between electrodes in deuterium gas at low pressures. The results are striking: a temperature of a million degrees centigrade was reached, and conclusive evidence of neutron and γ-ray bursts was obtained. This is the first time, as far as it is known, that these effects have been achieved. The methods of measurement are not stated, but such a temperature is much higher than any previously reported. From both points of view the work must be regarded as of first-class scientific interest.

Dr. Kurchatov described results disproving the correctness of the simple assumption that the gas is squeezed into the centre of the tube by the magnetic field of the current and heated up continuously during the period of the electrical pulse. Indeed the diameter of the discharge oscillates with a period of microsecond order, depending on the conditions of current, gas pressure, and so forth. At the moment of maximum compression, the neutrons are emitted in a very sharp spike much shorter than the electrical pulse. One may argue these neutrons are not "thermonuclear"; there are certainly intense electric plasma oscillations involving rapid mass motions of ions with very high velocities towards the axis of the discharge, and these are probably responsible for the neutrons rather than any mechanism remotely related to thermodynamic equilibrium.

Dr. Kurchatov is very pessimistic about the possibility of developments along the lines indicated leading to any practically useful results. After a few oscillations the discharge seems to hit the tube walls and a large loss of heat by conduction is inevitable, as well as disintegrations of the walls and contamination of the gas. The temperature of the gas is lowered and the gas itself is mixed with the decomposition products of the walls, so the neutron burst does not recur. He says there are reasons for thinking this unavoidable, and that other methods should be attempted.

An interesting by-product of the research is the occurrence (along with the neutrons) of bursts of γ-rays of energy 300–400 Kev. These occur although the voltage used is only 10 kV. The mechanism suggested by Dr. Kurchatov is too briefly described to be clear, but it may be very significant for astrophysical problems that such high voltages can occur in plasma oscillations.

In a sense, the work described by Dr. Kurchatov is negative, since it is shown that the most straightforward method will probably not work as a power source. The problem of making and maintaining temperatures of more than a million degrees centigrade without using excessive power in heating up, or disintegrating, walls, electrodes, and so forth is clearly a most difficult one, though one may hope for its solution in the long run. Dr. Kurchatov briefly suggests "the idea of stationary processes" but just what he means by this is not clear. There may also be methods of obtaining thermonuclear power without the use of a discharge at all, though it is hard to think of a really promising system.

The investigation of thermonuclear power is a fascinating subject, and is clearly worth a big scientific effort. On the other hand, at Geneva last year there appeared to be undue optimism in some quarters about its practical uses. In fact it would be rash to assume that, even if successful, a thermonuclear process would lead automatically to very cheap power. Certainly the deuterium in the sea would provide almost inexhaustible fuel for the world, but we must remember that present estimates show that there is probably enough uranium and thorium for about a thousand years. Thus for a long time thermonuclear power would have to compete economically with fission power. At present costs, for equal power, deuterium appears to be considerably more expensive than uranium, assuming that both can be used completely. Of course we are a long way from anything like a full utilisation of uranium, at least without involving high additional costs in chemical reprocessing; whereas the deuterium, if it could be used at all, would probably be used completely. Even so, it does not appear that there can be an order-of-magnitude difference in favour of deuterium in fuel costs, which anyhow are only a small proportion of total electricity costs. The economic question, therefore, turns mostly on whether one could build fission or fusion plants at the lower capital cost, and this is very difficult to answer. Quite possibly ways will be found to make genuine thermonuclear fusion possible, but it is likely to be a long time before fusion can establish itself as a successful rival to its elder brother, fission.

MACHINES, MANAGERS, AND MEN

The DSIR Report on "Automation' (H.M.S.O., 6s.) is useful rather than illuminatory. It was obviously designed to give the greatest number of people a clearer idea of the problems and possibilities of automation, and because of the wide catchment area it must of necessity repeat many of the generalisations that have been a regular feature of the Press in recent months.

The DSIR which now concerns itself greatly with human as well as technical research projects, rightly stresses throughout the report how much automation will depend on people. The trouble is that our social

skills are still much below our technical skills, and what the machine disposes man so often opposes. For this reason those who have a fair knowledge of the technical implications of automation might look with great interest to what the report says about research into the social and managerial problems which are brought into relief by automation, and particularly, by recent happenings in Coventry and on union platforms.

Such readers may be disappointed. They will find wise words directed at managers and workers, who will, we hope, read them very carefully and, even more important, do something positive about the recommendations. They will not, however, be made fully aware that much other work is being done to discover how and why men are what they are, and whether they can be organised more effectively for industrial and socially desirable purposes. There is, for instance, not even a mention of cybernetics and pioneer British workers like Dr. Grey Walter and R. W. Ashby, to say nothing of Norbert Wiener's published works, which are not even listed in the bibliography.

But then, where were the authors to stop? If, as they say, and many believe, the really difficult problems of automation are human rather than technical relationships, this fact does not make automation much more different or difficult to apply than mechanisation, about which, in many forms, we have written and talked for years.

The report does, in fact, nearly say this, but if the DSIR believes strongly enough that managers and unions already have enough background case material available to help them apply mechanisation, and automation, whether the Detroit or the straight variety, they should perhaps say so in a much stronger manner. It is a coincidence that another report* has just been issued which contributes at least as much, and many would say even more, to the solution of automation's problems than the DSIR report.

This compilation of technical trends with a list of books, conferences, and study projects, will be useful to many lay readers. What would be even more useful to those whose responsibility it is to introduce technical change is a follow-up which (*a*) keeps progressive managers in touch with advanced research on human reactions and responses, and (*b*) reminds other managers, by example, that successful methods of introducing change by any name you wish to call it are available if they only troubled to find and use them.

PLUS ÇA CHANGE, PLUS ÇA RESTE LA MÊME CHOSE

At first sight the new arrangements for the control of the Department of Scientific and Industrial Research appear to be following the Russian pattern of abandoning the cult of personality. Up to now there has been one man with executive responsibility for the Department's work, the Secretary, but control is soon to pass into the hands of an executive council. The present Advisory Council will be abolished.

This is the biggest change forecast in the report of a Committee of Inquiry under the chairmanship of Sir Harry Jephcott, Chairman and Managing Director of Glaxo Laboratories Ltd., and consisting of two high-ranking civil servants, the Chairman of the present DSIR Advisory Council and the Chairman of the Advisory Council on Scientific Policy. Hard on the heels of the report, a very terse one, came a Bill embodying the changes recommended by the Committee which has already passed all its stages in the House of Lords and is waiting attention in the Commons. There appears to be no reason why the Bill should not become law in a short time.

The report of the Committee of Inquiry is, in fact, an interim report and Lord Salisbury has stated in the Lords that the full report is not to be published. The interim report, laconic to a fault, makes several implied criticisms of the DSIR as it is at present, and a number of more outspoken ones. They seem to add up to one firm attitude, which is that there has not been enough control on the research being carried out in the DSIR's laboratories. The report says that this desirable control cannot be tight because directors of research must have considerable freedom if the work is to be of good quality. On the other hand, it must be effective.

The Secretary of the Department is at present, the Committee of Inquiry states, "faced with an impossible task. In addition to his other duties it is his business to co-ordinate, guide, serve and in some respects to control the centres where research is done." Under the present set-up DSIR headquarters do not and cannot supervise programmes of research. In an admirably succinct passage, seized on by the Press, the Committee says, "Much is started: but not enough is stopped. As a result, many of the programmes have become too diffuse or too uneven in quality." The Advisory Council is solely advisory and ministerial control is "rightly and necessarily light".

The constant burden of the Committee's remarks is that there must be a much greater degree of control of DSIR's research work. Every time control is mentioned, however, it is rapidly qualified by some phrase which underlines the Committee's opinion that the control should be light.

It is not relevant at this point to argue about the quality and timeliness of all the research on the DSIR programmes. Some of this may conceivably be out of date or useless, reeling along on its own momentum. A reading of the Department's latest annual report, for the year 1954–5, may turn up some evidence of duplication or the diffuseness and unevenness the Committee's report notices. The question is whether the changes forecast in the DSIR Bill are going to achieve the light yet effective control that seems to be the ambition of the Jephcott Committee.

The report says that "a number of distinguished scientists and industrialists whose professional authority will be recognised by all concerned, and particularly the directors" are to be appointed to the Executive Council. In fact, this is exactly what is done now with the Advisory Council. It already consists of such men, so there is no change of policy here. There may be a

* "Management Succession", Acton Society Trust.

sinister ring about the phrase "particularly the directors". Does this mean that, in the past, the directors of research, or some of them, have taken no notice of the advice handed to them by the Advisory Council? If so, this seems extraordinary. Surely the Council itself or the Secretary of the Department, has been able to deal with such recalcitrance, if it ever existed. It is difficult to imagine the Advisory Council's opinion being treated lightly or its advice flouted. Surely what must have happened in practice up to now is that the Advisory Council's views were treated more or less as law. Orders from an executive council may perhaps carry a little more weight, for on paper at least the Executive Council will have more authority than the old Council. It will have teeth. But there are any number of ways of getting round orders. Assuming that the directors will maintain their independence, as they must, they will find it far from hard to water down orders from the Council to the strength they would like. With all emphasis that the Jephcott Committee puts on control being light, there appears to be little enough difference between the two Councils and their effect on DSIR work.

At the moment the DSIR Station have Research Boards to overlook their progress. The new Executive Council will be able to appoint sub-committees to examine the programme of work with the directors. This again sounds like distinction without difference. It is not possible or politic, for a number of obvious reasons, to ignore the opinions of a director on his own research programme. It would be disastrous to try to run a research station in which the director's advice was ignored and he himself left to the mercy of a sub-committee whose word was law. Sub-committees will have to take the views of a director into account and the arrangement will clearly be little changed from what it is now.

One important advantage may result from the appointment of the Executive Council. The responsibility for most of this country's civil research will rest squarely on its shoulders. It cannot plead that all it can do is advise. The responsibility will be attractive to the right kind of person and there should be no lack of people willing to take it on. In addition, taking over executive responsibility may encourage the members of the Council to make forcing efforts to speed up the application of research results where they will do the most good. Criticism from outside of an executive council will cut deeper than it ever has of an ordinary body.

Much of the mystery, and the necessity of conjecture, arises from the shortness of the interim report. There is a strong case for the whole report to be published, if only to be able to see where the Executive Council will have to take hold and to see what success it will have.

In the meantime, before the Executive Council and Prof. Melville, the new Secretary, take over, the DSIR is freewheeling. This cannot be good for the morale of the staff or for the country.

FILMS AND BRITISH UNIVERSITIES

Films are always a difficult problem in universities. Their dichotomy, an artistic medium and a scientific research technique, has not yet been resolved in Britain. As an art medium films fall naturally within the province of such faculties as drama, philosophy, psychology, economics, and sociology; whereas scientific films as a research tool are frequently of great benefit to the natural science and engineering faculties.

The Drama Department at the University of Bristol took a courageous step, therefore, in calling a conference to consider the whole field of the relationship between the universities, film, radio, and television. A full report, edited by G. Wickham, is now available.* It should certainly provide the arts faculties with guidance and stimulus in their teaching and research work with these media of mass communication. Briefly the Conference concluded that a full course for undergraduates could now be given in these subjects, and that students could be acquainted with the techniques and aesthetics of these media. Realistically and practically, it was also agreed that radio, films, and television could not be fully appreciated unless some practical and technical instruction were included in these undergraduate courses acquainting them with the basic broadcasting and cinematographic production techniques. Research in universities co-operating with individuals and organisations engaged in the production of these media should be encouraged, and finally the field of audience reaction research should be developed. These conclusions are undoubtedly to be welcomed, and should greatly help to evolve an informed critical approach to film, television, and broadcasting.

Such, then, are the most recent suggestions for co-operation between the arts section of British universities and the media of mass communication. It is deeply to be regretted that this conference did not include any consideration of the interplay between the science faculties and films or television. Cinematography was born in the scientific research laboratory and has never deserted its birthplace. It has contributed greatly to researches on such varied subjects as cell division, solar prominences, psychological behaviour studies, crystallographic phenomena, and mechanical engineering. In all these the cine camera was found to be a unique recording instrument with access to different scales of time. Scientists all over the world have found the film a useful research tool to gain new knowledge, they have used it for the recording of their research, and through its medium they have often communicated their results to their colleagues.

Unfortunately cinematographic techniques are by no means easy to master, nor is the necessary equipment always at hand or cheaply procurable. It has therefore often been suggested that a pool of information, of skilled technicians, and of equipment, be formed at a university to make these facilities readily available to research workers. This proposal has so far been successfully operated only in Germany, where the Institut für den Wissenschaftlichen Film in Göttingen, under the able guidance of its Director, Dr. G. Wolf, has set a

* "The Relation between Universities and Films, Radio and Television." Published for the University of Bristol by Butterworths Scientific Publications, London, 1956.

very high standard of cinematographic research. The present organisation in Germany works through representatives of this Institute, each an academic research worker and an expert in scientific cinematography, at all universities (see p. 291). If a university department decides to use cinematography in its research, this representative will arrange for the experiment to be filmed by the Institute. Such a consolidated organisation has of course innumerable advantages, but the very fact that it is centralised brings disadvantages in its train. A system of priorities must necessarily be operative, and individual scientists may feel that their particular need could be met more rapidly if the necessary facilities were available in their own laboratory instead of at a distant centre.

In America a different situation prevails. Most American universities and colleges have an audio-visual centre which is primarily concerned with the preparation of teaching films and only occasionally with research films when required. These American centres are co-ordinated in the American Universities Film Producers' Association, a body which at present has 250 members.

For a number of years now the British Universities Film Council has been in existence to further the use of films in British universities. It has compiled excellent catalogues and card indexes, but has so far taken little interest in the development of scientific research films and the provision of facilities for their production. It is good news, therefore, to know that at its recent annual meeting at Bristol University it decided to investigate fully the whole subject of research films and of a central institute for scientific photography and cinematography. The Council should not hesitate in this decision, and a strong and representative committee should be set up immediately to investigate this question fully. Is the German Institute to be copied, or are the American audio-visual centres to provide the prototypes for British universities? How great is the need in this country for photographic and cinematographic centres at each university? Most medical teaching colleges have by now realised the vital importance of medical photography and cinematography in their work, and excellent results have been achieved in this field. The film unit at the University of Edinburgh is perhaps the first example of one in this country which has set itself wider objectives, and it is hoped that it will prove to be the forerunner of others.

In using films at universities the first and foremost question is always one of money. Equipment is expensive. Technicians will have to be paid, and photographic material must be provided in adequate quantities. The answer to this financial problem might well be solved along the following lines. The film industry could never have reached its present status without the unstinting labour which science and scientific research have bestowed upon it. Chemistry, physics, electronics, and engineering have contributed enormously to the present status of the film as an entertainment medium, and the time has now come for the industry to repay its debt to science. Should not the film industry, headed as it is in this country by J. Arthur Rank, set up fellowships at universities? Should they not provide the funds for the universities to make research films and to use these techniques for their own benefit? Many other industries have found in the past that it has paid them handsomely to subsidise pure research at the universities, and the film industry will not find it otherwise. The British Universities Film Council should press forward with its inquiry at the earliest possible moment, and it should resolutely appeal for funds to carry forward this important work.

A LOCUST GAINS ITS WINGS

The desert locust (*Schistocerca gregaria*) is one of the most harmful of the migratory locusts which periodically denude hundreds of square miles of vegetation.

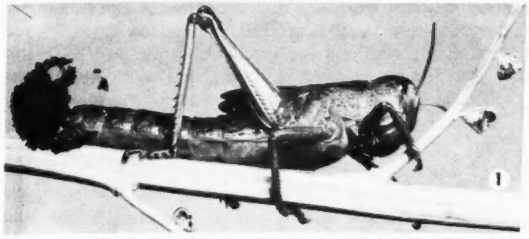
The desert locust normally lives a solitary life in the dry grasslands and deserts from Africa to the Punjab. When desert locusts reach plague proportions they swarm in billions and start migrating as "hoppers"—immature nymphs unable to fly. At the stage when these hoppers undergo a final moult and emerge as free-flying adults, the locusts start on their ravaging migration. The photographs here printed, taken by Jack de Cuziat, show, step by step, how the nymph of *S. gregaria* is transformed into the voracious adult desert locust.

Photographs of this nature are notoriously difficult to take as frequently the requirements of lighting cause the object to be overheated. A high light level is essential, to have sufficient depth of focus, and extension tubes are required between lens and camera. M. Jack de Cuziat, of Paris, has solved these difficulties very skilfully.

SOLAR ENERGY PROGRESS

The only criteria worth considering for any solar-energy device today are its economy and its efficiency. Many different sorts of equipment have now been made by enthusiasts, usually simple efforts but occasionally

Description of figures on opposite page: (1) When it is about to moult the hopper, whose rudimentary wings do not enable it to fly, usually climbs the stem of a plant, which it grips tightly with its legs while it bursts out of its old skin. (2) The locust emerges in its new form from the back of its old shell. Here the tergum, the hard shield on the back, just behind the head, is beginning to be forced up and split open. (3) The tergum has split open and the adult insect is beginning to emerge. (4) The head of the adult locust has emerged (*right*), and the rest of the body and wings are guadually pulled out. (5) Most of the body and wings are now free of the old skin, the "exuvia". (6) The giant hind legs are nearly free from the old skin, and the moist wings begin to uncurl. (7) One hind leg is free, and soon the entire adult locust will have left the exuvia and will wait for its wings to uncurl and dry. (8) Both hind legs are free, and the adult insect has entirely emerged. (9) As the locust rests on its twig, moving its antennae from side to side, the wings elongate and begin to take their final form. (10) The wings are now almost completely unfurled.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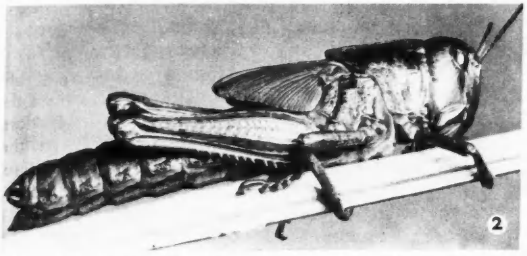
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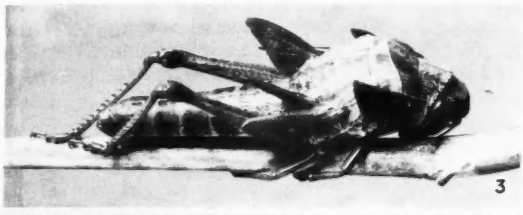
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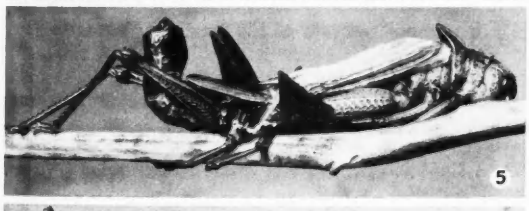
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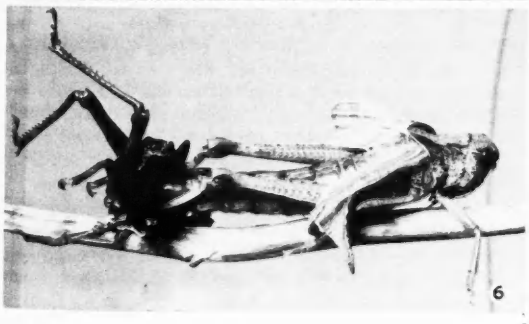
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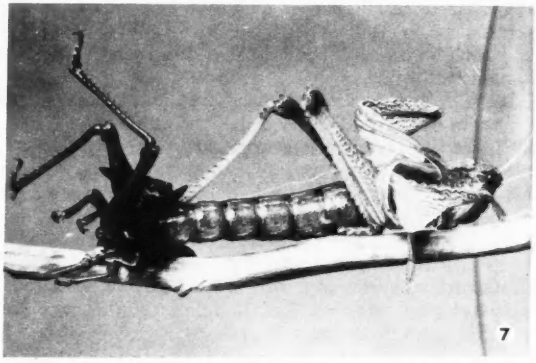
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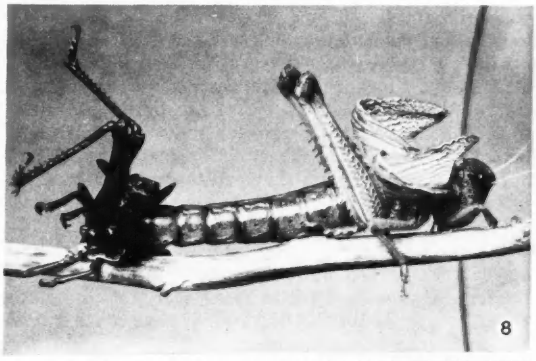
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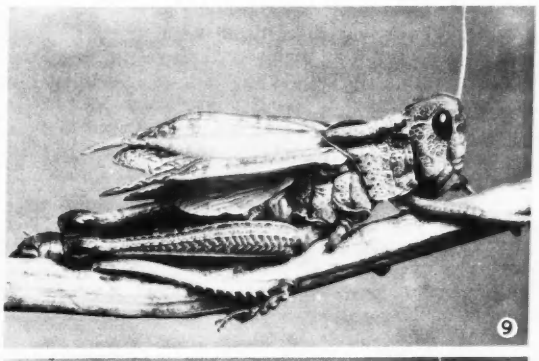
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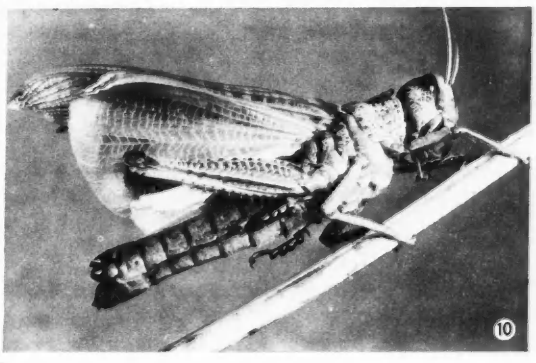
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adaptable to production in quantity. They work, in so far as they do what they are supposed to do, by means of radiation from the sun. The trick can be done; honour is satisfied.

Most of the devices, however ingenious or complex, are no more than rather large demonstration toys. They do indeed work, but the energy they produce could in most cases be more cheaply had from ordinary electricity-supply systems or internal-combustion engines. Moreover, they are all costly. To the inhabitant of an advanced country there is little, if anything, to be gained from any solar-energy device yet produced. In underdeveloped countries endowed with plenty of sunshine, however, any such device is still very attractive in principle because the need is so urgent.

Even so, a gadget for cooking a meal by sunshine, unless it is very cheap, is not what is chiefly being sought. The underdeveloped countries need power. So a solar-energy device must produce *useful* power, be comparatively inexpensive, and usable on an economic basis. By these criteria taken together all devices have so far failed, even the spectacular power-producing unit made by Trombe in France. For this, paraboloidal mirrors of very accurate shape are necessary, and these are expensive.

If a heat engine such as a steam turbine could be run efficiently with flat collectors or with very little optical concentration, then power of a useful sort could be produced economically from solar energy. It is to this that Dr. H. Tabor of the Israeli National Physical Laboratory in Jerusalem has turned his attention, and he has produced some very interesting ideas.

His argument starts from the classical axiom that the efficiency of any heat engine depends on the hot temperature of the working substance (assuming that the cold temperature is not much above the usual). As he says, modern turbines operate with steam as hot as 350°C and more, but no reasonable collecting system for solar radiation has been able to produce such a temperature.

What then limits this temperature? A flat plate absorbs solar radiation and gets hotter. As it does so it begins to lose heat by conduction, convection and radiation. Eventually a steady state is reached when the gain from the sun is equal to the loss to the surroundings. The temperature of this steady state for a flat glass plate insulated on the back to prevent loss by conduction and protected from the wind is about 113°C. If the collector is used to heat water, this subtracts heat and the steady-state temperature is still lower. As Dr. Tabor has pointed out, existing domestic solar heaters of the flat-plate type never produce *boiling* water. An 80-fold optical concentration is necessary with curved mirrors to raise the steady-state temperature to 400°C, and such a concentration is impossible without elaborate and very expensive optical systems.

For a flat-plate system the loss by radiation is, he says, about twice the loss by convection. Loss by conduction can be largely avoided by careful insulation. So if the radiation loss could be drastically reduced a steady-state temperature might be reached high enough for an economically useful turbine.

But the conditions for good absorption of radiation are also those for good emission. It is a matter of surface quality. As everyone knows from his schooldays, a shiny metal surface is a bad absorber of radiation falling on it and a bad emitter of radiation when it is hot, whereas a black surface is a good absorber and a good emitter. So, according to present knowledge, the surface conditions that make a bad emitter conserve the heat will make a bad absorber, and so will get little from the solar radiation. The properties of the surface are mutually contradictory for our purposes.

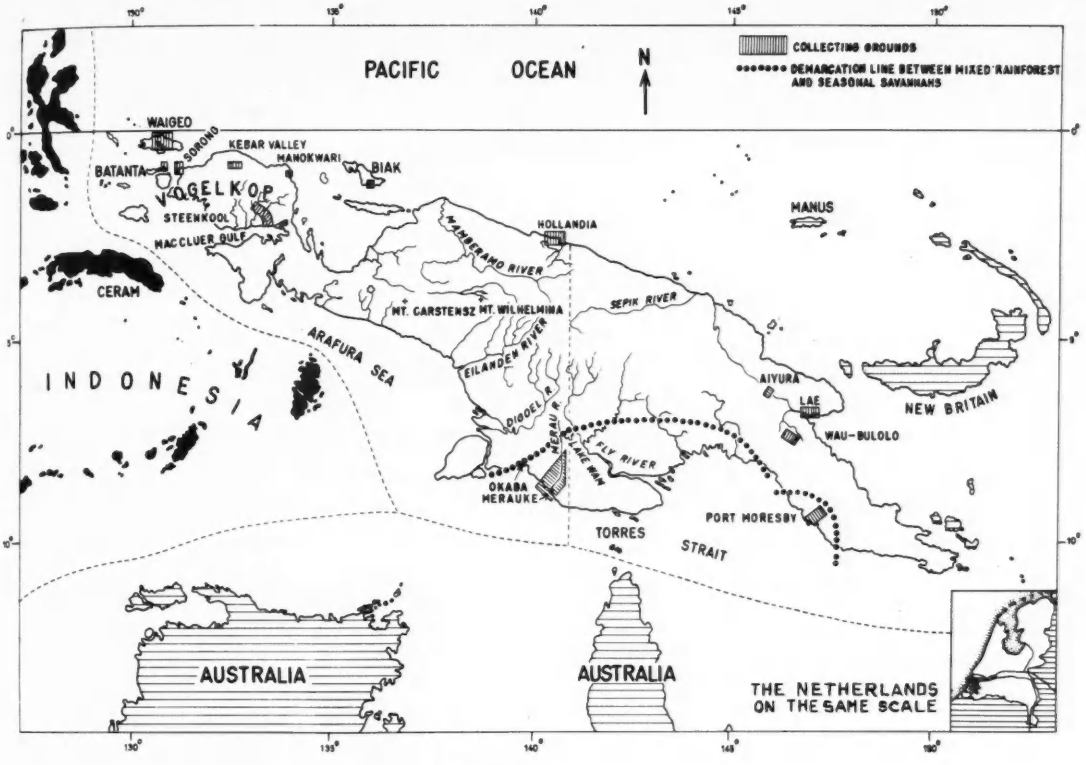
But suppose a surface could be devised to be selective in its radiation properties. The range of wavelengths in solar radiation is from 0·3 to 2·0 microns (3000 to 20,000 angstroms), corresponding to the radiation from a body heated up to over a thousand degrees centigrade. The wavelength of the radiation emitted by a body heated up to only a few hundred degrees is much longer than 2·0 microns (20,000 angstroms). If a surface could be made to be a good absorber of solar radiation but a poor emitter of radiation of much longer wavelength, then the way would be open for getting a steady-state temperature of the order required for working a turbine.

Polished zinc has a surface with such properties, but it only absorbs about half the solar energy it receives. Dr. Tabor has succeeded in producing surfaces that are much better absorbers up to 2·0 microns and yet still comparatively poor emitters of the longer wavelengths. The underlying idea is to take a bright metal, which is a bad emitter, and make it a good absorber by putting on a very thin black layer, so thin that it is transparent to very long wavelengths and thus has no effect on the basic metal surface, which for these long wavelengths is therefore still a poor emitter.

One way of doing this is to get nickel in a black form by electrodeposition on to silver. With this the efficiency of absorption has been raised to about 90% while the emissivity is still only about 6%. Another device tried is to dye the very thin oxide film always present on aluminium.

Spectrographic measurement has shown that the change from high absorption to low emission, for black nickel on silver, takes place at a wavelength of just about 2·0 microns, which is what is required. By changing the thickness of the deposited layer and varying the conditions of electrodeposition, the emissivity and absorptivity can be controlled. So far an absorptivity of 94% has been achieved.

A second suggestion by Dr. Tabor is to reverse the conditions. Instead of having the highly-polished surface underneath the absorbing coating, why not have a black surface underneath a good heat reflector? He has also experimented with a silvered undersurface on ordinary glass. He calculates that if the emissivity of any of the selective devices could be reduced tenfold, solar-energy engines of 16% efficiency could be made with the help of a fairly simple optical system.



Map of New Guinea and surrounding areas.

BOTANICAL EXPLORATION OF NEW GUINEA

P. van ROYEN

Rijksherbarium, Leiden, Netherlands

Like a giant legless dinosaur New Guinea rests on the roof of the Australian continent. From its nose to the end of its tail this monster measures 1500 miles, a distance almost equal to that from London to Rome, and reaches a width of 500 miles. The spine of the island is formed by a range of mountains reaching up to 16,000 feet altitude in Mount Carstensz in the Dutch section, gradually diminishing in size towards the Australian. The rest of the island is composed of extensive swamps, low hilly country and savannas which are flooded for part of the year; in the other months the ground dries out and bursts open with wide cracks. From the high central ranges several big rivers flow to the sea, the biggest ones being the Mamberamo river in the Dutch section and the Sepik and Fly rivers in the Australian. The rivers allowed many explorers to reach the interior of the island and one of the smaller, the Merau river, made it possible for us to reach the Fly river starting from our base in Merauke. In size approximately 93,000 square miles, its population is only about one and a half million. Loosely described as Papuas, a name derived from the Portuguese word "papua", which means frizzle-haired, no generic term covers all inhabitants of New Guinea adequately because they present an extraordinary mixture of racial types and languages.

CLIMATE

The climate of New Guinea is essentially tropical, is characterised by high temperatures and humidity, and gives rise to a luxuriant mixed tropical rain-forest. However, the southern parts of the island are subjected to seasonal changes. From December to April extensive and prolonged rains flood the area and many trees flower, but in the other part of the year a strong, consistent, and dry south-eastern trade-wind coming from the Australian deserts scorches the earth, causing many trees, such as *Bombax malabaricum*, the forest cotton-tree, to lose their leaves.

EXPEDITION TO STUDY THE VEGETATION

The vegetation can roughly be divided into an evergreen tropical rain-forest and a seasonal vegetation.

FIG. 1. *Araucaria cunninghamii* Sweet., var. *papuana* Lauterbach (Araucariaceae) on northern slope of the Tombia Mountains south of Kebar valley, 60 miles west of Manokwari, Netherlands New Guinea.

FIG. 2. Early morning in a chestnut forest (*Castanopsis* spp., Fagaceae) behind Steenkool, Netherlands New Guinea.

FIG. 3. *Tristellateia australasiae* A. Richard (Malpighiaceae) climbing over shrubs along edge of mangroves along Roefei river north of Sorong, Netherlands New Guinea.

FIG. 4. *Coelogyne* sp. (Orchidaceae) in oak forest (*Quercus* sp., Fagaceae), in Tombia Mountains south of Kebar valley, 60 miles west of Manokwari, Netherlands New Guinea.

FIG. 5. *Faradaya* sp. (Loganiaceae) climbing along *Heritiera littoralis* Aiton in forest on southern bank of Merau river, north-east of Merauke, Netherlands New Guinea.

The first type is found north of a line running approximately from Okaba in the west to Port Moresby in the east, while the second type covers the regions south of this line. In the evergreen vegetation several types can be distinguished: the mangroves, the mixed rain-forest from the lower regions and the foothills, the mountain vegetation, and the alpine vegetation.

These vegetations have been explored during the last hundred years but only by a small number of expeditions, whose activities were mainly directed either to a narrow belt along coasts or rivers or to the main ranges in the centre of the island. This caused a markedly unbalanced picture of the vegetation of New Guinea and so one of the main purposes of the Dutch Botanical Expedition to New Guinea in 1954 and 1955 was to begin filling up the gaps in the knowledge of the vegetation of the lower regions slightly behind the coast. Because of their malarial swamps, many previous attempts to explore these regions were defeated; however, the advent of modern drugs now enabled people to withstand this illness and other tropical fevers and to penetrate these neglected areas.

Also for practical reasons it was necessary to know more about the forests, and to find the useful trees and their estimated numbers. Sponsored by the "Rijksherbarium", one of the most important centres for the study of the Malaysian and Pacific floras, financed by private and governmental sources and enjoying the material and financial support of both the Australian and Netherlands administration in New Guinea, this expedition was a rather remarkable one. It put an end to the period when incidental trips were made to certain chosen areas, and it stood on the threshold of a new era of systematical exploration of the botanical resources. Also, though some regions had to be explored for their scientific interest, co-operation with the Forest Department enabled a then almost non-existent civil service to investigate the relatively unexplored possibilities of this densely forested island. Thirdly, in this expedition only one scientist directed the activities in the field. He was, moreover, the only European in a team unarmed against possible attacks by natives. The hard work of carrying supplies and photographic gear, the collecting of materials and cutting down of trees, was carried out by Papuas chosen from the ranks of the Forest Department or locally hired. These men had a deep affinity with nature, and they were delighted to discover that there were peoples of other races really interested in the flora of their country. This resulted in a feeling of unity and common aim between the members of the team, and nothing pleased the men more than to be able to discover some new feature of interest, such as a rare plant and its use.

Very occasionally another European used to join the team, and would find opportunities for studying ethnology and languages.

THE VOGELKOP PENINSULA

Scientifically the main features of the vegetation of New Guinea were known, but many details were still

missing, and economically the forest resources had never, or hardly ever, been explored. Combining these two tasks the expedition started its work around Sorong, situated in the north-western corner of the Vogelkop Peninsula (Bird's Head Peninsula), a region explored only a few times in a rather hurried way. It therefore offered a splendid opportunity for extending the knowledge of the vegetation of this part of the island.

The Vogelkop Peninsula has no main ranges like the central part of the island but the country is built up by numerous low, often strongly broken-up, hills with some mountains reaching 10,000 feet in the Tamrau Range. Most of the peninsula is covered by a tropical rain-forest, but the northern shores of the MacCluer Gulf carry a belt of mangroves up to 20 miles wide and 180 miles long, a muddy belt which is only to be crossed by way of the rivers. It can be developed into one of the richest sources in the world of tannic acid. Recent investigations showed that these mangroves (*Rhizophora* ssp.) contain a higher amount of tannic acid per tree than in the same type of vegetation in the Philippines, which was supposed, for a long time, to have the highest quantity.

Immediately behind the mangroves a narrow belt of brackish swamps is found in which *Intsia bijuga* (*Caesalpiniaceae*), the so-called iron-wood, reaches its full development and dominates this area. The wood of this tree becomes rusty brown after felling and sinks immediately when thrown in water. Being rather hard, it is much used for building. Also it is one of the main timbers now exported.

The rest of the Vogelkop Peninsula is covered by a mixed tropical rain-forest with slight local variations. Many of the ranges in this area consist of elevated coral-reefs and limestone cliffs, and this fact gives rise to a vegetation characteristic for this type of soil. The *Intsia bijuga* is again found here in large quantities. Two more representatives of the *Caesalpiniaceae* turned out to be present in rather large quantities, *Pterocarpus indicus*, and a new species of *Pericopsis*, both useful for furniture manufacture. The tree which is a true indicator of limestone-containing areas appeared to be *Mimusops elengi* of the Sapotaceae, and later we used to try to find this tree merely in order to establish the certain presence of limestone.

One of the most important local variations in the tropical rain-forest of the peninsula is the domination of *Araucaria cunninghamii* var. *papuana* in the Kebar Valley, half-way between Sorong and Manokwari. This valley, with a length of about 40 miles and a width of 1 to 6 miles, is bordered in the north by hills and jagged mountains reaching up to 10,000 feet in Mount Tamrau, covered by oak-chestnut forests in the lower parts, and southern beech forests (*Nothofagus* ssp.) in the higher parts. The summits are covered by conifers: *Papuacedrus arfakensis*, *Podocarpus*, and *Dacrydium* ssp. In these Tamrau ranges on Mount Nettoti, never explored before, our expedition found a heath vegetation with many rhododendrons, vacciniums, and other Ericaceae. Usually this type of vegetation is met with in the mountain regions above 8000 feet, but here it was found at about 5500 feet.

To the south the valley is bordered by hills that reach 5000 feet in Mount Wabari and gradually pass into the broken area of the interior of the Vogelkop Peninsula. The foothills are covered by grass-plains which the natives keep artificially in existence by burning, so that they may hunt there. This burning and the subsequent pushing back of the primary forest, is one of the main problems in New Guinea, as elsewhere in the tropics. In the last few hundred years many areas have been deprived of natural vegetation, the primary forest being replaced by these grass-plains. This not only induces changes in the local climate but also promotes soil erosion, forcing the natives to cut and burn down still more forests for agricultural purposes till the newly gained soil is exhausted again and the land is left to the coarse grasses which cover this area rather quickly. Unchecked, this process will lead to a complete deforestation of many regions. Fortunately the number of natives in New Guinea is still so small that this deforestation remains within controllable proportions, but with better social and medical care brought by Western civilisation, it is worth while keeping an open eye for these problems by teaching the increasing number of natives better ways of agriculture and care for the soil and its vegetation.

Besides these large plains, which also cover a part of the valley, the hills south of the Kebar Valley bear a *Quercus-Castanopsis* forest, in which the most striking feature, however, is formed by the hoop pines (*Araucaria cunninghamii* var. *papuana*). These tall trees, up to 250 feet high, belong to a very ancient family which is found in New Guinea with two species. In the Australian part of the island many forests of these pines are found around Wau and Bulolo. This induced the Bulolo Gold Dredging Company and the Australian Government to start a plywood timber mill in Bulolo. In order to establish such a possibility in the Dutch half of the island, our expedition explored the Kebar Valley. A reconnaissance party of the Forest Department had reported these hoop pines a few weeks before our trip in this valley, and we were asked to estimate the number of pines. Long trips in the valley unfortunately revealed the number to be about 3000, far too few to start a timber mill. The advice given to the Forest Department was to reforest the grass-plains with Araucaria seedlings and to start a mill with the abundance of iron-wood, oaks, chestnuts, and beeches as a base.

THE NORTH COAST

The type of vegetations described above occurs over most parts of New Guinea, but along the north coast there are two big swampy areas, one on either side of the Mamberamo river and the second along the Sepik river. These areas are almost impenetrable and are covered with sago palms (*Metroxylon sagu*), copal trees (*Agathis labillardière*), and mixed rain-forests. The first two species are very useful as a source of food and of copal, a resin extensively used for various purposes in the paint industry. Another feature worth mentioning

is the *anisoptera-hopea* vegetation around Lae. Though these two species do not dominate the forests, they are the most important owing to their size. These tall trees, up to 130 feet high, yield a valuable timber which is often used in the Australian part of New Guinea for building purposes. It is also exported. Surprisingly the iron-wood so common in the Dutch part is not found here, and according to field-reports this species is not found east of the Sepik river. This fact led some botanists to accept this river as the boundary between the Malayan and Australian element in the vegetation of New Guinea, but too many species are found on both sides of the river for this view to be tenable.

THE SOUTH

A different type of vegetation in the lower regions was found south of the line running from Okaba to Port Moresby. As has been stated before, this is an area under the influence of seasonal changes, with a dry south-eastern trade-wind from April to December and long spells of rain during the other part of the year. The vegetation of this area consists of grass-plains, savannas, and scattered forests. The dominating trees are the thick-leaved eucalyptus and the white-stemmed melaleucas, which, with their willow-like leaves are very striking, and even ghostly, when seen in a bright moonlit night with the wallabies hopping among the trees like eerie gnomes.

This typical seasonal vegetation had never been thoroughly studied in the Dutch part, and as it was important to learn more about these regions, our team explored the area between Merauke and the Fly river. We were the first botanical team to penetrate so far into these unknown territories. This area also suffers from burning. However, the population in this part of New Guinea is decreasing, and the tropical forest seems to be advancing southwards owing to less frequent burning. Botanists are in fact gradually beginning to believe that many savannas and deserts are anthropomorphic and do not constitute a natural climax-vegetation.

In these southern regions the climate is drier and sunnier. During the expedition we took many photographs in different atmospheres, so that comparisons could be made on the influence of humidity and sun in the different regions on sensitive material. I had four cameras with me, two of them movie-cameras. Most of the pictures and movies were in colour, but the best results were obtained with an old-fashioned 9 by 12-centimetre camera that had to be loaded with black-and-white-sensitive glass-plates. However useful and beautiful colour-pictures are, for scientific purposes ordinary black-and-white pictures of large size are more satisfying. Colour pictures were satisfactory only for close-ups, whatever the type of film.

RAUKI AND WAIGEO ISLANDS

One of the purposes of our expedition was to retrace the steps of two French botanists, Gaudichaud-Beaupré and Dumont d'Urville who visited the island of Rawak off the north coast of Waigeo in 1818 and the island Waigeo itself in 1823. Parts of their collections are lost and so our task was to make a new collection of the vegetation of these two islands mentioned and to compare their present-day vegetation with that of about 150 years ago.

The island of Rawak, the present-day Rauki Island, consists of two hills, the southern one reaching about 100 feet, the northern about 1000 feet, separated by a flat sandy plain with grasses in the centre and the usual coastal vegetation along the margins. Comparing the reports of 150 years ago with the present vegetation, the only difference seems to be that the sandy central plain has become broader and is more covered with vegetation. Only on the northern peak did we find any endemic species, but apparently a voodoo is lying over the vegetation of this island as part of my collection was destroyed by fungus before it arrived in the herbarium.

For seven weeks a study of Waigeo Island, situated north of Sorong, was carried out in continually pouring rains. The island has a dumb-bell shape caused by the Majalibit Bay, which very nearly splits the island in two halves. The island is almost exclusively built of elevated coral-reefs and limestone cliffs along the coasts but the interior of the peninsulas are very low and muddy. When crossing this area we had to wade through waist-high mud, but this proved too annoying and we finally walked in the rivers which, with their gravelly beds, were a far better path. The limestone cliffs and coral-reefs are covered with an open but tall forest in which a *Palaquium* species, *Manilkara fasciculata*, and a palm, *Golubba moluccana*, are the dominating trees. The muddy central parts of the peninsulas have a mixed rain-forest with an abundance of *Dillenia* species. Other parts, however, are covered by frankincense trees, *Vatica papuana*.

Though the rains hampered our movements and put a serious strain on men and materials, the results obtained were remarkable as it was finally established that the vegetation of Waigeo is essentially Malaysian and has almost no Australian species.

CONCLUSION

The vegetation of New Guinea is a mixture of Malaysian and Australian species, but a large number of endemic species occur, owing to the age-long isolation from either Australia, Malaysia, or both. For a long time it was doubted whether a definite line could be drawn between the Malaysian, the New Guinean, and the Australian flora. We found that the existence of such a line is not probable and it can be said instead that the western parts of New Guinea have a Malaysian influence—demonstrated, for example, by *Intsia bijuga* which is absent from the eastern parts—and the eastern part an Australian influence—demonstrated by *Araucaria cunninghamii* var. *papuana* which is found in large numbers in the Australian section but far less in the Dutch. Apart from this, another interesting feature of the flora of New Guinea was discovered, as a link seems also to exist with the West Australian vegetation and not with the Queensland flora alone.

METHANE—A NEW BRITISH FUEL?

LESLIE T. MINCHIN, B.Sc., M.Inst.Gas E., F.Inst.F.

A new source of fuel should be an important news item in a country so badly in need of fuel and power as Britain. Strangely enough, the extraction of methane from coal mines, which is the subject of a recent OEEC Report, has been developed to a high pitch in the Saar basin, but English achievements make a poor showing. South Belgium also has a system for collecting this gas from the coal mines in that area.

The basic idea of methane drainage was described in L. T. Minchin's article "Methane in the Service of Man", published in DISCOVERY, February 1953. Coal as it lies in the earth has a considerable quantity of methane compressed in its interstices and in the rocks above it. It is there because it has been formed as a by-product in the complex chain of chemical changes which have turned the forest debris of several hundred million years ago into the coal we know today.

When mining operations are commenced on the coal seam the gas which has been stored so long is evolved. In most coal mines very large volumes of air are circulated through the working districts, but in spite of this the air may easily contain as much as 1% methane when it goes back into the atmosphere. A large mine can in this way blow a million cubic feet or more of methane into the air every day. This represents the heat equivalent of 40 to 50 tons of good coal wasted.

During the years when coal was plentiful and unemployment in the mining industry a serious social problem, no one bothered about this waste of fuel, but since the war serious attention has been paid to it in several European countries. It is found that by drilling holes into the rock strata lying immediately above the coal a gas can be drawn off which contains sixty to seventy per cent of methane. The gas drained off in this way is prevented from getting into the air of the mine and so the likelihood of accidents is reduced. Carried up to the pithead by a vertical pipe it provides a supply of fuel which can be used for a variety of commercial purposes.

ADVANTAGES OF METHANE DRAINAGE

The process has, therefore, a double advantage. Instead of "robbing Peter to pay Paul", we can *pay* Peter as well. The OEEC Report quotes a case of a colliery in the Saar which makes a profit of a hundred thousand pounds per annum (2*s.* per ton of coal) by the sale of methane gas. At the same time it very often happens that the rate at which the coal is extracted can be increased because the mine is made safer. Thus an additional financial benefit is conferred on the colliery.

In both Belgium and the Saar there exist pipeline companies, a form of organisation which is unknown in England at the present time. These companies carry on business normally by buying coke-oven gas, distributing it to the places where it is wanted, and selling it again to the local gas undertaking or direct to the large factory. A company of this kind is well fitted to take advantage of methane drainage and in both countries it is largely as a result of their efforts that the gas has been extensively used.

An obvious use for the gas is to fire the steam boilers which provide power for the colliery. This, however, is a function which can be performed by a low-grade fuel such as coal with a high mineral content. And if facilities exist for transporting the gas away from the colliery it is likely that the use of gas for boiler firing will be uneconomic. As a high-grade fuel, free from sulphur, it can be put to much better uses.

In Belgium there is a large factory situated between Mons and Charleroi which makes special alloy steels and which uses methane from coal mines almost exclusively. Open-hearth furnaces, bloom heating ovens, soaking pits, etc., are all heated in this way, and not a wisp of smoke can be seen above the site. In both Belgium and the Saar, methane is used for driving the large compressors which send the coke-oven gas on its long journey to other parts of the Continent. In the Saar some of the gas is compressed and used as a fuel for motor lorries, but this is a decreasing market. In the same district the methane is being used now to replace coal gas in the heating of coke ovens. It is common practice to use some of the coal gas which is produced in the manufacture of coke to heat the actual retorts. This of course decreases the amount of gas which can be sold, but if instead one can fire the ovens with methane an equivalent amount of coal gas can be sold to the pipeline companies.

One may well ask whether the gas cannot be used direct for domestic purposes. The answer is that it is too different in properties from ordinary coal gas to be added to the latter except in quite small proportions. To make more use of methane in this way it must undergo a chemical transformation by what is known as a "cracking" or "re-forming" process. Belgium has a large re-forming factory at St. Aldegonde, and the Saar has a smaller one in the middle of their coalfield. Although there is inevitably a certain loss of energy attending this transformation, the gas which results can be added in quite large quantities to coal gas without affecting the user.

Any user of fuel requires that his supply shall be a reliable one, and as the output of methane from a coal mine is intimately bound up with the rate of coal production it cannot be said that a single mine is a very reliable source. The practical solution to this, and it has been adopted on the Continent, is to link up a number of coal mines in a methane grid. Belgium has thirty mines linked in this way. Even the complete cessation of a gas supply from one colliery does not seriously interfere with such a system. In Britain, unfortunately, we have not progressed so far, and although there are two collieries which are selling gas, they function as isolated units. Naturally, the quantities obtained are much smaller; if computed in terms of therms per

day we have: Saar, 100,000: Belgium, 75,000: Britain certainly under 10,000.

THE SITUATION IN BRITAIN

All mines are not "gassy", which means that in many instances the methane, if it ever existed, has escaped through porous strata and very little is encountered in the workings. However, nearly half the coal mined in Britain comes from "gassy" mines, and in the opinion of the OEEC Commission this could produce 400 million cubic metres per annum: this works out to 400,000 therms per day, equivalent to about 2000 tons of coal per day. As Britain is having to import coal from the U.S.A. at a very high price to make up the gap between demand and supply, it seems that a determined effort should be made to recover some of this mines gas which is now going to waste.

There is one other project which is being sponsored by the Ministry of Fuel and Power at Stafford. This aims at the utilisation of the "up-cast air" which contains, as we have seen, 1% or less of methane. Although the concentration of fuel is so low, it is possible to operate a gas turbine with it by employing a large pre-heater to effect combustion under pressure. Although this scheme may have some value, it is open to two serious objections. In the first case the size of the plant required to deal with such a bulky and dilute fuel is very great, and in the second case the development of methane drainage schemes such as we have described above tends to rob the up-cast air of even the small amount of methane which it has previously contained. On the whole it does not seem very likely that this will prove a very practical method for commercial operation.

INFLUENCE OF TEMPERATURE ON FRESHWATER ANIMALS

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"I'd rather be a cold cat than a hot dog." To those who knew the silent films and the adventures of Felix the Cat, that quotation will be familiar. Whether Felix, one of his two main ambitions achieved, was snug in a comfortable seat before a fire, or whether he had just been discovered and thrown out into the snow, his temperature was the same. All mammals and all birds have this ability to maintain their temperature constant, but mammals and birds, though the largest and most conspicuous of its members, make but a small contribution in number of individuals and number of species to the animal kingdom. The rest, reptiles, amphibians, birds, insects, and all the other invertebrates, have a body temperature which differs little from that of the surrounding water or air and fluctuates with it. In their lives temperature is a factor of the utmost importance; as it gets warmer they move faster, eat faster, and grow faster. That statement does require some qualification, but as a rough generalisation it holds good.

Most animals are active over a certain range of temperature, generally somewhere between the freezing point of water 0°C and blood heat of mammals 37°C, but exact information about the range is available for a few species only. Perhaps most is known about a Canadian fish called the speckled trout (*Salvelinus fontinalis*). It is not found in streams where the temperature exceeds 20°C, which most bathers would not consider very warm. In experiments it was found that fish placed in a tank which was warmer at one end than the other would select a place with a certain temperature. Actually the temperature selected depended on the temperature in which the fish had been living previously, but, whatever this had been, they always moved away from water warmer than 19°C if there was colder available. The most efficient use of oxygen was made at 16°C, quickest growth was at 14°C, and the fish travelled farthest after an electric shock at 10°C. This lower figure may have been due to the fact that the fish used in the experiment had previously been at a temperature of 4°C. It seems that the speckled trout thrives somewhere about 15°C; at temperatures much below this the fish are sluggish, and, as the temperature approaches 20°C and the point at which they cannot live permanently, they lose weight even though provided with superabundance of food. The speckled trout is a cold-water fish. In contrast, the common carp is a warm-water fish though performance figures as precise as those just quoted are not available. It is known, however, that the European fish-farmer is pleased if carp gain 1 lb. in a year whereas in Israel that amount may be gained in a month.

Another study, important because two closely related species were compared, is that of Blunck (1924) on the water-beetle *Dytiscus*. *D. marginalis*, the common species in Britain, does not grow at all below 10°C though it does feed, but completes the first stage of development in 42 days at 10°C, 26 days at 12°C, 10 days at 15°C, and 3 days at 25°C. The rate of development of later stages, or instars, is similar but not identical. On the other hand, *D. semisulcatus* starts developing at about 5°C and completes the first instar in 12 days at 10°C, at which temperature *D. marginalis* is only just starting to grow at all. Both species occur in the northernmost parts of Europe but in Britain larvae of *D. semisulcatus* are found in winter, those of *D. marginalis* in summer, so that the two are

not present together during the growing period when food requirements are greatest. At about 27°C development of *D. marginalis* is quicker than at lower temperatures but a number of specimens die or emerge as monsters.

DALLINGER'S EXPERIMENT

Why are these creatures confined to a certain temperature range? Living matter is remarkably adaptable and many readers will be familiar with the experiments of Dallinger in the last century. He started with a culture of flagellates that were killed at 23°C, but by increasing the temperature very gradually over a period of years, he eventually had them living at 70°C, which is 159°F. The writer's bath thermometer is marked "hot" at 105°F and the scale stops at 130°F. The experiment was then brought to an end by an accident. Doubtless many other animals are similarly adaptable but are prevented from extending their range by other factors. Competition with other species is probably one of the most important of these, and certain stream-dwelling flatworms provide an illustration. Beauchamp and Ullyott (1932) found a few streams in the Balkans where either *Planaria montenegrina* or *P. gonocephala* occurred alone, and in these both species extended down from the spring to a point where further spread was apparently prevented by too high a temperature. *P. montenegrina* stopped at about 16°C, the other at about 22°C. In most streams, however, the two occurred together and then *P. montenegrina* occupied alone the upper part of the stream down to a point where the temperature was about 13°C and beyond *P. gonocephala* was the only species. Perhaps *P. montenegrina*'s chances of adapting itself to a higher temperature are small because competition with *P. gonocephala* keeps it out of warmer water. It must also be stressed that a species may be confined within a certain temperature range by factors that have nothing to do with temperature. How this may come about was revealed by the researches of Muirhead-Thomson (1951) on the mosquito, *Anopheles minimus,* in Assam. The larvae are found only in streams, which never get quite as warm as nearby ponds and pools. When the fatal temperature was studied, it was found that the ponds got too warm for *A. minimus* larvae during the day, though not for certain species that did occur in them. On the face of it, this appears a likely explanation of the distribution of the species; but in fact further work showed that it had nothing to do with it. The larvae of *A. minimus* occurred in streams because that was where the female placed her eggs; she was not influenced by temperature, for she laid in the small hours when ponds and streams were cool and at about the same temperature. It seemed that there was some characteristic smell about the stream which attracted *A. minimus* females.

On the other hand there may be some creatures which, unlike Dallinger's flagellates, are constitutionally incapable of adapting themselves to a different temperature. It would be a difficult thing to prove.

TEMPERATURE AND RANGE OF SPECIES

Temperature, then, in general is a factor that limits the range of species. Great Britain, for example, is not warm enough, or only warm enough in the south, for certain Mediterranean species such as the European Pond Tortoise, and too warm except in springs or high up on mountains for certain others, such as the flatworm *Planaria alpina.* This European Pond Tortoise is now found only in the southern half of France, but it did occur in Britain once at a time when the climate is thought to have been warmer, for its shells have been found in peat. *P. alpina* was probably widespread during the Ice Age but is now confined to the upper parts of streams where the water is cold.

There are endless instances in the literature of animals apparently limited in range by temperature, and plenty of speculation about how temperature acts, but exact information based on experiments is very much scarcer. It is the purpose here to present as much proven fact and as little speculation as possible. It is convenient to start at the low end of the temperature scale and work upwards, but first it must be pointed out that the story is a difficult one to present in an orderly way. The animals themselves are diverse, particularly in their life histories, and the number of ways in which temperature could limit them is great. First there are fish and other animals that have a comparatively long adult life and breed once a year. Second may be classed such creatures as *Gammarus,* the freshwater shrimp, which also spend their adult lives in water but which differ in that several generations are brought forth in the year. Third come insects with a greater difference between young and adult, and a great diversity among themselves; *Ephemeroptera* (may-flies) and *Plecoptera* (stone-flies) generally live a year or more in the aquatic stage and then leave the water for a short adulthood during which little except reproduction is achieved. Dragon-flies and mosquitoes are similar except that the adult life is longer, and the latter may achieve many generations during the favourable season. Beetles and bugs are different again in that the adult stage also is spent in the water.

Any gardener knows that some plants can stand more frost than others and it would be no use planting in the Lake District certain species that flourish at sea-level at Torquay. For others an untimely frost is more disastrous than intense cold in mid-winter. In the aquatic environment, however, this is much less important because water freezes only at the top and, except for a few that live in very shallow ponds or pools, its inhabitants are never exposed to a temperature below freezing point. The nearest example is provided by the small-mouth bass, introduced into certain Canadian lakes under the supervision of Prof. D. S. Rawson (1943). He showed that reproduction was stimulated by a quick rise in temperature in the neighbourhood of 16°C and that successful development was only achieved if the temperature remained above 19°C. If it dropped, the males deserted the nests and the eggs died. This happened in two of the four years when Rawson was observing them and he concluded that the

locality must, therefore, be very near the northern limit of the range of the species.

Many animals are inactive at low temperatures. Salmon, for example, seek out deep pools and lie inert as long as the temperature is below 7°C. The ability to fast probably involves some adaptation and is akin to hibernation; any cold-blooded inhabitant of the temperate regions must have some means of survival during cold weather. Obviously, however, this inactivity cannot go on too long and some species are probably barred from northern latitudes for this reason.

TEMPERATURE AND DEVELOPMENT

Higher up the scale, temperature is probably most important on account of its effect on rate of development. An exception is *Dytiscus marginalis*, which can only survive the winter as an adult and must get through the young stages during the warm season. If a species cannot grow up one summer there is no reason why it should not tide over the winter and finish the process next year, as indeed some frogs and newts often do. But it may happen that, in latitudes or at altitudes where this becomes regular, the rate of reproduction is not fast enough to keep pace with mortality; or, if there is some similar species that can complete development within one season at that temperature, that species will oust the slower grower. On the whole, rate of development is less important for those animals that have one generation a year, and some period in the life-history when growth of the fully grown stops and others can catch up; the rate of development is, however, extremely important for those with several generations in a season. A particularly good example of this has just been worked out by Hynes (1955), who has studied the four species of shrimps *Gammarus*. The three most interesting are the common *G. pulex*, the recent immigrant from America *G. fasciatus*, and the brackish-water *G. duebeni*. In Ireland *G. duebeni* is common in fresh water and *G. fasciatus* has been found once or twice, but in England, Wales, and Scotland *G. duebeni* is confined to brackish water except in one or two places and *G. fasciatus* has only been found in a few rather peculiar localities. *G. pulex* occurs in England, except for a small region near the Lizard where *G. duebeni* occurs in fresh water, in Wales, and in Scotland, except the extreme north. It has not been found in Ireland. All the facts accord with a suggestion that *G. pulex* is a comparatively recent immigrant which has not quite colonised the whole of the mainland yet and has not reached Ireland. In fresh water *G. duebeni* and *G. fasciatus* cannot compete with it, and the former is driven back into water too saline for *G. pulex* and *G. fasciatus* confined to places apparently unsuitable for *G. pulex* for other reasons. What is the nature of this competition? Hynes has studied the rate of reproduction of these shrimps both in the field and in the laboratory and found that, at the temperatures prevailing in Britain, *G. pulex* produces more young in the course of a season than either of the other two, and this appears to be the reason for its success against them. At slightly higher temperatures *G. fasciatus* reproduces remarkably rapidly, and were our climate to become a little warmer there is every reason to suppose that *G. fasciatus* would turn the tables on *G. pulex*.

Some critical event in the life-history—breeding of certain fish is an example—may not take place unless the temperature rises above a certain value.

The effect of temperature is thus generally indirect at unfavourably low values, but at the other end of the scale it is more often direct. Trout and *Dytiscus* have been mentioned and Muirhead-Thomson provides a further example. At about 37°C larvae of *Anopheles minimus* stop feeding and at higher temperatures they are killed; in two hours at 39°C, one hour at 40°C, and in five minutes at 41°C.

TEMPERATURE AND DIAPAUSE

Temperature is often an important factor in diapause, but of the animals in which this phenomenon has received detailed study, none is aquatic. It remains, therefore, to mention only the ways in which temperature interacts with other factors to produce unfavourable conditions. Pleskot (1953) has suggested, though not proved experimentally, that an ephemeropteran in Austrian streams emerges only early in the summer because, as the water gets warmer later on, it does not hold enough oxygen for the full-grown nymphs. She believes that there is a critical time as the adult is nearing completion inside the nymphal skin when the transport of oxygen from the water to the tissues is difficult and a high concentration is essential. The common pond-snail can obtain all the oxygen it needs by diffusion through the body surface at moderate temperatures, but must come to the surface to fill its lung in warm water. This limits the depth at which it can live (Hunter 1953).

Neomysis vulgaris, a small shrimp that is often found in brackish water, dies at about 24°C in fresh water but can tolerate an increasingly high temperature in progressively higher salinities. Various other crustacea are able to tolerate lower salinities at higher temperatures and are therefore able to penetrate farther up estuaries in warmer countries.

READING LIST

Beauchamp, R. S. A., and Ullyott, P., "Competitive relationships between certain species of fresh-water triclads", *J. Ecol.*, 1932, vol. 20, pp. 200–8.

Blunck, H., "Die Entwicklung des *Dytiscus marginalis* L. vom Ei bis zur Imago", *Z. wiss. Zool.*, 1924, vol. 121, pp. 171–391.

Hunter, W. R., "On the migrations of *Lymnaea peregra* (Müller) on the shores of Loch Lomond", *Proc. Roy. Soc. Edinb.* B., 1953, vol. 65, pp. 84–105.

Hynes, H. B. N., "The reproductive cycle of some British fresh-water Gammaridae", *J. Anim. Ecol.*, 1955, vol. 24, pp. 352–87.

Muirhead-Thomson, R. C., "Mosquito behaviour in relation to malaria transmission and control in the tropics", 1951, London: Arnold.

Pleskot, G., "Zur Ökologie der Leptophlebiiden (Ins. Ephemeroptera)", *Österreich. zool. Z.*, 1953, vol. 4, pp. 45–107.

Rawson, D. S., "The experimental introduction of smallmouth black bass into lakes of the Prince Albert National Park, Saskatchewan", *Trans. Amer. Fish Soc.*, 1943, vol. 73, pp. 19–31.

SHELL STRUCTURE IN THE NUCLEUS

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Even among physicists, the discovery of nuclear fission excited little comment except in the then small circle of nuclear specialists. Yet it was perhaps the greatest discovery of the century, the foundation of the "Atomic Age" as we now ineptly call it. It has opened up the way to a completely new kind of engineering—and to weapons of unprecedented powers. The nucleus, the source of the energy we are just beginning to tap, was studied only in the uppermost pinnacles of the Ivory Tower of pure science. The physicists who pioneered this work would have been amazed, if not shocked, to learn that their research could ever have a practical application, let alone a devastating and destructive one.

Nuclear physics is but one stage in the continuous scientific inquiry into the "Constitution of Matter", a title used by Lord Rutherford for lectures he gave in the Cavendish Laboratory, Cambridge, and used before him for lectures given by Lord Kelvin. The inquiry has led through the gross properties of matter, such as motion, gravitation, heat, and electricity, to their understanding in terms of molecules and atoms in motion and to the analysis of atoms themselves into central nuclei surrounded by swarms of electrons. By 1939, when the fission of the uranium nucleus by neutrons was announced, much was known of the structure of the nucleus but very much more was unknown. Even today, this is still true, despite the growing knowledge of the elementary particles of physics—some being the permanent bricks of atomic nuclei, others with but a transient existence in cosmic rays, the temporary products of violent collisions between nuclei.

Nevertheless, since 1939, several important new ideas have been evolved which help to give us a useful mental picture of the nucleus. The construction of models, corresponding more or less accurately to aspects of reality, plays an important part in the development of a new science even if they are later discarded as misleading or hampering. One such concept which has proved its worth in the last few years is the *Shell Model* which is concerned with regularities and recurrences of properties from nucleus to nucleus analogous to the periodic system of chemistry. The name *shell* comes from the language of chemical physics to describe configurations of electrons having particular chemical stability, which form the basis of the physical theory of chemical behaviour.

ATOMIC SHELLS

If the chemical elements are arranged in order of increasing atomic number, well defined chemical properties recur at regular intervals. For example, the elements 2 (He), 10 (Ne), 18 (A), 36 (Kr), 54 (Xe), and 86 (Rn) (the rare gases) are all inert and form no true chemical compounds in any circumstances. The elements immediately following them, that is with atomic numbers one greater in each case, are 3 (Li), 11 (Na), 19 (K), 37 (Rb), 55 (Cs), and 87 (Fr). They are metals in the uncombined state (the alkali metals), monovalent in combination and chemically very reactive.

The inert character of the rare gases can be explained if we consider that the electrons in their atoms are arranged in very stable "closed shells". It needs a large amount of energy to extract an electron from a closed shell, while any electron added to an atom is so loosely bound that it is readily lost again. The atom is therefore perfectly stable, having no tendency either to give or take electrons and thus to form molecules with other atoms.

The chemical behaviour of the alkali metals is determined by the simple fact that all except one of the electrons in each atom fit into closed shells, the remaining electron being so loosely bound that it can easily be detached to form a bond with another atom.

The physical properties of the two series of elements show similarities in the same way as do the chemical properties. The first series are all gases, the second all metals. The ionisation potential, or quantity of energy required to abstract one electron from an atom, is particularly high in the case of the rare gases because of the stable nature of the closed shell configuration and very low for the alkali metals because the extra electron is loosely bound and therefore easily detached.

The quantum laws governing the motion of electrons in the atom provide the reason for the closed shell concept. Without being too rigorous, we can say that electrons can only move in discrete quantum states or *orbitals*, and as a consequence of Pauli's Exclusion Principle not more than one electron can go into any one orbital. The normal state of an atom is one in which the energy is as low as possible, a condition attained when the electrons are packed one by one into the lowest energy orbitals. The shells arise because the orbitals are arranged in groups; in each group the orbitals have nearly equal energies, but different groups have quite different energies. Thus the lowest energy orbitals constitute a group of two, the K shell (so called, historically, because of its connexion with the K line in the characteristic spectrum of the element). Then come two groups of eight, the L shell (named from the L x-rays) and the M shell, followed by two groups of eighteen, the N shell and the O shell and finally a group of thirty-two, the P shell. It is unnecessary to go beyond this point, because these orbitals are sufficient to hold all the electrons of any known atom. The sequence 2, 8, 8, 18, 18, 32, representing the numbers of orbitals in the successive groups, can be explained by the nature of orbitals in the field force of the atom. It can be deduced from the laws of quantum mechanics in a quite straightforward way, the details being given in standard textbooks of atomic physics.*

* *See*, for example, M. Born, "Atomic Physics", Blackie, 1944.

The chemical character of an atom is almost completely determined by the number of electrons required to make up a closed shell or the number in excess of closed shells. The actual number of electrons in a neutral atom is fixed by the charge on the nucleus as the two must precisely cancel each other. It is clear then that atoms with 2, 10, 18, 36, 54, and 86 electrons consist of closed shells and are therefore inert because the electrons form a full K shell, K+L shells or K+L+M shells respectively. Atoms with 3, 11, 19, 37, 55, and 87 electrons all have one loosely bound electron in excess of the closed shells and thus have a monovalent character in chemical reaction.

THE STRUCTURE OF THE NUCLEUS

Nuclei are composed of two basic units, protons which are electrically charged, and neutrons which are not. Apart from their different electrical properties protons and neutrons are similar. Their masses are very nearly equal, they both are endowed with *spin*; and, associated with their spin, they have a magnetic moment. Because of this we can usefully imagine them as little spinning particles magnetised along their axes. On account of the similarity between protons and neutrons it is convenient to have a generic name for them and call them *nucleons*. Nucleons are kept together in a nucleus by forces of attraction much greater than the electrical forces familiar in the physics of atomic structure. As yet little is known in detail about the origin of the nuclear forces, and even the law relating force with distance and direction of the spin axis is uncertain. One fact with important consequences is definitely established, that is that the forces are effective over only a very short range. It is also known that nucleons obey Pauli's Exclusion Principle so that not more than one nucleon of either kind can occupy a "completely specified quantum state".

The nucleus is a quite well defined volume which may be pictured as a roughly spherical region in which nucleons move about, subject to nuclear forces and to the laws of quantum mechanics. The radius of a nucleus can be measured experimentally in a variety of ways and is well established. From the observed facts we can draw the interesting conclusion that the volume occupied by a nucleus is proportional to the number of nucleons it contains. As the mass is also proportional to the number of nucleons, the density of *nuclear matter* (i.e. of nucleons inside nuclei) is effectively the same for all nuclei. Modern theories agree in regarding the nucleus as a region of fairly constant density, with fairly well defined boundaries outside of which the density rapidly falls to zero. This picture furnishes the background for the ultimate explanation of the *shell* structure pattern analogous to electron shells outside the nucleus.

NUCLEAR SHELLS

Protons and neutrons, as electrons, are subject to quantum laws of motion and are restricted to discrete orbitals arranged in groups according to their energy. But since the forces which hold the nucleons together are very different in character from the forces acting on electrons the grouping of energies is quite different. Another difference between atomic and nuclear shells arises because there are two kinds of nucleon but only one kind of electron. The nuclear shell pattern is thus a double one. There are shells of protons and shells of neutrons.

Closed shells can be identified by many unmistakable indications if one has the physical techniques to observe them, and we now recognise that closed nuclear shells occur with the following nucleon numbers, 2, 8, 20, 40, 50, 82, and 126. There are indications of less well-marked shell structures associated with nucleon numbers 6, 14, and 28, these are sometimes called *closed subshells*.

The numbers 2, (6), 8, (14), 20, (28), 40, 50, 82, and 126 are often called the *Magic Numbers* of nuclear physics. Those interested in explicit formulae for numerical progressions will see that the magic numbers fall into two classes represented by

$$\frac{1}{3}n\,(n^2+5)=2,\ 6,\ 14,\ 28,\ 50,\ 82,\ 126\ \ldots$$

and $$\frac{1}{3}n\,(n+1)\,(n+2)=2,\ 8,\ 20,\ 40,\ 70,\ 112\ \ldots,$$

where n runs through the sequence 1, 2, 3 . . ..

The alpha particle (the nucleus of helium) is an example of a *doubly magic* nucleus having *two* protons and *two* neutrons. It thus contains simultaneously a closed shell of protons and a closed shell of neutrons and is therefore such a stable entity that it appears regularly as a product of radioactive breakdown. Another doubly magic nucleus is the predominant isotope of oxygen, $^{16}_{8}O$, with eight protons and eight neutrons. The other isotopes of oxygen have, of course, eight protons and are *singly magic*, with a closed shell of protons but not a closed shell of neutrons. The isotopes of tin (atomic number 50) similarly all have a closed shell of protons as do the isotopes of lead (atomic number 82). The most abundant isotope of lead, $^{208}_{82}Pb$, has also enclosed a shell of 126 neutrons and is another example of a doubly magic nucleus.

EVIDENCE FOR THE MAGIC NUMBERS

The sequence of magic numbers is quite simple and regular, yet it took a long time to discover it. The consequences of shell closure in nuclei do not force themselves on the attention of physicists in the way that chemical valency directs attention to electron shells and their effects are masked by another type of regular pattern in nuclei which overlays the gentler rhythm of nuclear shells. This is the *even-odd alternation* which shows itself in the tighter binding of nuclei with an even number of protons and an even number of neutrons, (*even-even* nuclei) compared with *even-odd* or *odd-even* nuclei. *Odd-odd* nuclei with odd numbers of both protons and neutrons are, with some important exceptions, so loosely bound that they are radiocative. This even-odd alternation gives a recurrence of particular stability whenever two protons and two neutrons are added.

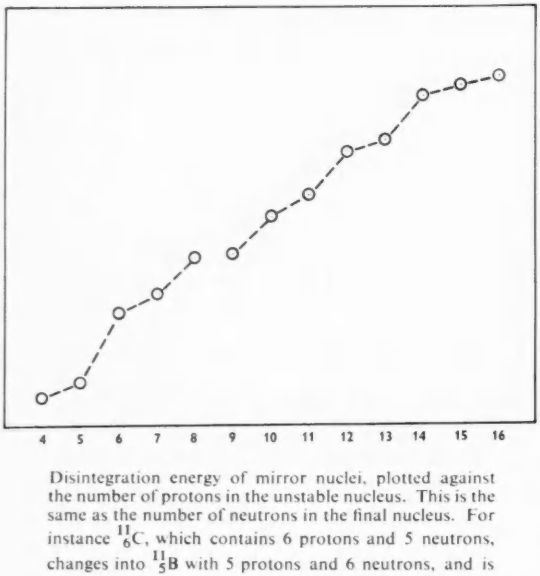
This had previously suggested that nuclei contain alpha particles as stable sub-groups within their structure.

One direct way of detecting the closing of nuclear shells is to measure the energy necessary to remove a nucleon from the nucleus. In the case of electrons there is a sudden drop in the ionisation potential on passing a closed shell, similarly with nuclei there is a very marked decrease in the corresponding proton or neutron binding energy. However, it is only in the last few years that systematic measurements of these binding energies have been available, and this was not the way in which the magic numbers were first discovered. Indeed, the first indications relied on very indirect, and in many cases uncertain, pieces of evidence. Long before any systematic measurements of nuclear binding energies were available it was known that some nuclei were stable and some radioactive. The radioactive nuclei transmute spontaneously into more stable nuclei. Nuclei with the same total number of nucleons are called *isobars* because they have the same atomic weight. Generally only a limited number of isobars exist as stable nuclei. The unstable ones undergo a transformation in which either a neutron emits an electron and becomes a proton or, vice versa, a proton absorbs an electron from the atomic swarm (or, alternatively, emits a positive electron) and becomes a neutron. This possibility of change limits the potential variety of stable nuclei; it takes place only if energy can be released by it. Hence the stable nuclei are, broadly speaking, those which are most tightly bound since tight binding is synonymous with low energy.

The number of protons in the stablest of a set of isobars might be expected to vary in a rather regular way with atomic weight, and superficially it does so. But a careful study of the pattern of stable nuclei shows well marked irregularities due to shell structure. An example will show the kind of evidence from which the deductions are made. If we consider the nuclei of atomic weights 31, 33, 35, 37, 39, 41, 43, 45, . . ., then for each of these there is only one stable nucleus. For instance, the nucleus of atomic weight 31 is the nucleus of phosphorus with 15 protons and 16 neutrons. Returning to the series, if we write down the number of neutrons in the stable nuclei, we get 16, 17, 18, 20, 20, 22, 23, 24, ... The double jump from 18 to 20, the repetition of 20 followed by a double jump to 22 is interpreted as a result of the extra stability of the shell of 20 neutrons. The argument is by no means direct, for the closed shell at this point is not the only reason for a break in the sequence. It is a fairly simple consequence of the electrical repulsion between protons which gives them additional energy in the nucleus, that the bigger a nucleus is, the more does stability favour nuclei containing more neutrons than protons. Since the numbers are necessarily integers, there must somewhere be a sudden jump by two units in the regular progression to accommodate this trend. If there were no shell effect, the series would be of the form 16, 17, 18, 20, 21, 22, 23, 24, ..., with one double jump. Instead we find the double jump, no jump, double jump sequence.

Considering now the proton series, we get 15, 16, 17, 17, 19, 19, 20, 21, ... Without shell closure there would have been one single repetition, for example, 15, 16, 17, 17, 18, 19, 20, 21, ... to allow for the increasing tendency to neutron excess. The complete absence of 18 is due to the closed shell of 20 neutrons.

It is clear from this example that the evidence must be evaluated very carefully. It would have been possible to deduce a peculiarity associated with 18 protons instead of 20 from the information cited, but fortunately nowadays more precise and complete information than the stability of certain nuclei is available. For instance we can get quantitative information by comparing the energies released in the radioactive transformations from unstable to stable nuclei as shown in the graph. This plots the energy released in the radioactive decay of a special class of nuclei called *mirror nuclei*. These are pairs, one partner having one more proton than it has neutrons, the other one more neutron than it has protons. For example, carbon 11, $^{11}_{6}C$, has 6 protons and 5 neutrons, while its mirror nucleus, boron 11, $^{11}_{5}B$, has 5 protons and 6 neutrons. The proton-rich partners of this group are radioactive, emitting positive electrons (*positrons*) to transform themselves into their mirrors. According to the shell model, one proton in a quite definite nuclear energy level changes, by emitting a positron, into a neutron in exactly the corresponding energy level. The change in energy is due mainly to the reduction in the electrical energy of repulsion resulting from the change in electric charge of the nucleus. The energy from nuclear forces is virtually unchanged by the substitution of a neutron for a proton in the same energy level. Now the electrical energy of the nucleus depends on the size of the region occupied by protons in the various energy levels, when protons are in different shells they occupy regions of different sizes.



Disintegration energy of mirror nuclei, plotted against the number of protons in the unstable nucleus. This is the same as the number of neutrons in the final nucleus. For instance $^{11}_{6}C$, which contains 6 protons and 5 neutrons, changes into $^{11}_{5}B$ with 5 protons and 6 neutrons, and is plotted as 6.

This effect is quite clearly shown by the break between the mirror pair number 8 in the figure (O15, N15), and the pair numbered 9 (F17, O17), in the line joining the experimental points. This indicates the start of the new shell after the magic number 8. The proton which changes into a neutron in No. 9 ($^{17}_{9}$F $^{17}_{8}$O) is the ninth nucleon of its kind and is a new shell.

The relative abundances with which nuclei are distributed in nature are influenced by the magic numbers. Although it is not yet agreed how the elements found in the earth were originally formed, any reasonable hypothesis predicts a greater abundance of stable and tightly bound nuclei, in agreement with fact. The extreme abundance of oxygen compared with the relative rarity of fluorine, for example, can be correlated with the doubly magic character of $^{16}_{8}$O, which is the predominant isotope of oxygen. The high abundance of tin (50 protons) compared with the elements near it in the periodic table is another example as is that of lead (82 protons). It has been argued that the high abundance of iron in the earth (mainly $^{56}_{28}$Fe) arose from the abundance with which the doubly magic but radioactive nucleus $^{56}_{28}$Ni with 28 protons and 28 neutrons was produced in the genesis of the elements.

Nuclear spectroscopy, until recently imprecise and ill understood, now gives the clearest evidence of shell structure. Greatly improved techniques have resulted in much systematic information about the energy levels of nuclei and the gamma-rays emitted when transitions from one level to another occur. This tells us a great deal about the nuclear orbitals themselves and the way in which they group together into shells can be studied directly. It has been found that the energy levels of a nucleon moving inside a nucleus correspond approximately to those expected in a field of *nuclear matter* of constant density occupying a spherical region of the diameter observed in experiments. There is one important qualification, a strong interaction between the *spin* of a nucleon and its translational motion must be postulated. Early experiments on nuclear forces did not suggest so strong an interaction and even now its origin and nature is still rather mysterious. Had there been no such *spin-orbit interaction* as it is called, the sequence of magic numbers would have been 2, 8, 20, 40, 70, 112, ... Its effect is to shift the grouping in such a way that for the bigger nuclei the shells come at 50, 80, and 126 rather than at 40, 70, and 112.

The shell model has been enormously fruitful in the recent developments of nuclear physics but it also has severe limitations. It gives a very reasonable interpretation of the structure when the nucleus is in its lowest energy level or in an excited level of fairly low energy, but it is quite inadequate for dealing with highly excited nuclei. There are other aspects of nuclear structure on which it has very little to say and where other kinds of simplified approach are more rewarding. But within its proper limits it has proved unexpectedly useful and it is one of the problems of modern physics to explain why so simple an approach as the shell model is so successful in describing such a complex structure as an atomic nucleus.

GEOLOGICAL STRATA AS A STORAGE SPACE

In our June issue, p. 224, we described the progress of attempts in Britain to make use of some of our coal reserves by means of operations conducted from the surface. Another new process which has something in common with this is the underground storage of gas. This uses not coal measures but porous sandstone beds, usually in strata so moulded by geophysical forces as to be in the form of an "anticline" or dome. Such beds are normally saturated with water, brine, or oil; gas forced down at high pressure will lower the liquid horizon and in this way a storage space is provided.

The system has been in use in the U.S.A. for many years; used-up natural gas- or oil-bearing strata are normally employed, gas being pumped in during the summer months so that it can be drawn upon at times of peak demand in the winter. In north-western Europe only a very little natural gas has so far been discovered and it has been necessary to search for the right kind of rock formation in other places. The quest has been successful in Germany, and near Hanover a brine-saturated sandstone layer is now being used as a huge reservoir for manufactured gas. This storage layer is 600 feet below the surface, and a pressure of 35 atmospheres is needed to squeeze out the brine so that gas can enter. When extra gas is needed in the cold days of winter, all that has to be done is to open the tap at the top of the borehole leading down to the storage layer.

The importance of this German venture is likely to be considerable. Coke ovens can make gas at a uniform rate summer and winter and this is the main source of fuel gas in Germany where the gasworks is much less important than in Britain. Gas pumped underground during the summer can be released when most of it is needed in the winter and the capacity is vastly greater than that of any man-made tank. This one layer holds an amount of gas equal to about five times the combined volume of all the gasholders in Western Germany. It only came into use in the winter 1954–5, and so far 1700 million cubic feet of coke-oven gas have been compressed into it.

The enterprise was one needing a good deal of faith, for manufactured gas is an expensive commodity to pump into the earth in such a quantity as this. Moreover, the American underground storage systems are all in places which have until recently contained natural gas for geological epochs, so their gas tightness was assured. No such positive guarantee existed at Hamburg, but so far the courage of the engineers has been justified and no leaks have been reported. The story was told to the Institution of Gas Engineers at their Summer Meeting in London last May by Dr. Gummert, of the Ruhrgas A.G.

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

News of IGY programmes from China, U.S.A., France, Australia, and Poland make up this month's chronicle. Main activity still centres in Antarctica, where lengthy preparations must precede the beginning of the research work during the coming year. Inevitably interest will be focused on the spectacular, costly, and time- and labour-consuming preparations, but other activities in other parts of the world dealing with oceanographic and ionospheric research will be reported soon. This column is already attracting world-wide interest, and scientists actively engaged on IGY activities are invited to send news about their research projects to the Editor of DISCOVERY.

Planning

The Arctic conference, as previously announced, took place in Stockholm between May 22 and 25. It was attended on behalf of Great Britain by Mr. J. M. Wordie, chairman of the British National IGY Committee and Master of St. John's College, Cambridge. The resolutions were not available for this edition.

The conference of the Antarctic Working Group in Paris has now been postponed and will take place from July 30–August 3.

The Western Region Conference will take place in Rio de Janiero in July.

The French Programme

The French contribution to the International Geophysical Year was drawn up by a National Committee consisting of members of the Académie des Sciences, affiliated to the International Council of Scientific Unions. The committee's work was divided into two main sections: one charged with studying the programme of work on longitudes, presided over by M. Danjon, director of the Paris Observatory; the other, dealing with geophysical work, headed by M. J. Coulomb, director of the Institut de Physique du Globe de Paris. The National Committee, and the various sub-committees set up to consider in detail what it was possible and desirable to carry out, had the 166 observatories, laboratories, meteorological and hydrological stations of France and French overseas territories as the basic means at their disposal. It was decided that the credits asked for should go to re-equip the most useful of these stations and also to increase very greatly their activities during the Geophysical Year. Three major decisions were made: a large development of research facilities in the Kerguelen islands (sub-auroral belt), the creation of a new station at Tahiti Orstom, and the carrying out of a French Antarctic expedition to Adélie Land, which would include the installation of two important new polar stations.

In 1953 the French Government granted the main part of the credits asked for. The National Committee was forced to abandon projects for rocket-firing, though there is still a chance that these may be taken up by the French Ministry of Defence. The total sum was about 250 million francs per year, 1954–9; more than half of this was allocated to the Antarctic expedition. The body appointed by the Government to carry out the plans of the National Committee is drawn from the National Centre for Scientific Research. The Chairman of this body and of the National Committee is the R.P. Pierre Lejay; the address of both is: 119 rue St. Jacques, Paris V.

For the international study of longitudes, France is using three stations. One is the Paris Observatory, to which the Bureau International de L'Heure is attached; the second is the Alger Bouzaréa Observatory in Algiers, which played an important part in the first world longitudinal operation in 1926 and which is now being extensively re-equipped; and the third is the observatory and station at Tananarive in Madagascar. Here an important study will be made of cosmic radiation, probably in correlation with radio-galactic sounds.

One of the most ambitious re-equipment schemes is being carried out by the Sahara sub-committee at Tamanrasset, where, by 1957, work on meteorology, ozone, terrestrial magnetism, the nocturnal sky, and the ionosphere will be carried out. The seismographic installation will be increased by two horizontal electromagnetic seismographs. The observatory and station at Bangui (equatorial belt) is also called on to play a particularly important part. Here measures of absorption and winds in the E and F layers will be made, and also an attempt to measure primary cosmic radiation at high altitudes by photographic nuclear emulsions carried by stratospheric balloons which will platform at from 30 to 40 kilometres from one to three hours.

During the IGY, France will provide nine out of the 134 magnetic stations, four observation posts for solar radiation, and will maintain ten out of the 135 stations of the international network of ionosphere measurements. Of the eleven polar stations at present envisaged, France will provide two in Adélie Land.

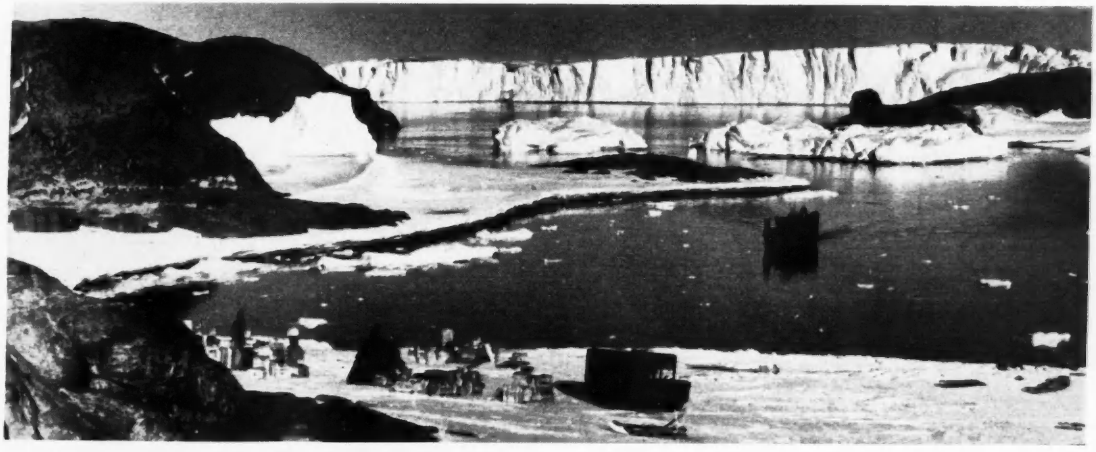
A French polar expedition wintered in Adélie Land in 1951, gained much experience, and left behind certain installations. This Antarctic expedition, a major part of France's effort during the IGY, gives France direct access to the heart of the polar region. Adélie Land probably contains the true magnetic Pole, which is subject to secular movement and the position of which can be abruptly altered by heavy magnetic storms. The normal position of the true magnetic Pole is probably close to the auxiliary station called "Plateau" which is some 300 kilometres nearer the Pole than the main station at Pointe Géologie. Three men will inhabit Plateau Station during the IGY, and their work, apart from keeping themselves alive, will be concerned with meteorological observations, measurements of the magnetic field around the Pole, glaciology, actinometry, and an attempt to measure the exchange of matter and energy between the inlandice and its atmosphere. Some fourteen scientists will live at Pointe Géologie from the beginning of 1957. The principal work of this station, apart from meteorology and ozone measurements, will be measurements of magnetism and earth currents, ionosphere recordings, and a particularly important study of auroral phenomena with the most advanced instruments. Pointe Géologie will be directly linked with the station at Resolute Bay in Canada, which is almost exactly on the same geo-magnetic latitude and on the same line of geo-magnetic force.

The polar ship *Norsel*, which has already taken the first part of the expedition to its base, is being used for gravity measurements, for liaison between France and Adélie Land, and for meteorological observations. It has already played a part in the French

FIG. 1 (*left*). Ile des Petrels, Adélie Land. (*Photo Imbert.*)

FIG. 2 (*centre*). The bay and the landing beach, Ile des Petrels, Adélie Land. (*Photo Pommer.*)

FIG. 3 (*below*). A Weasel drawing a heavily-loaded sled on the landing beach, Pointe Géologie (*Photo Pommer.*)



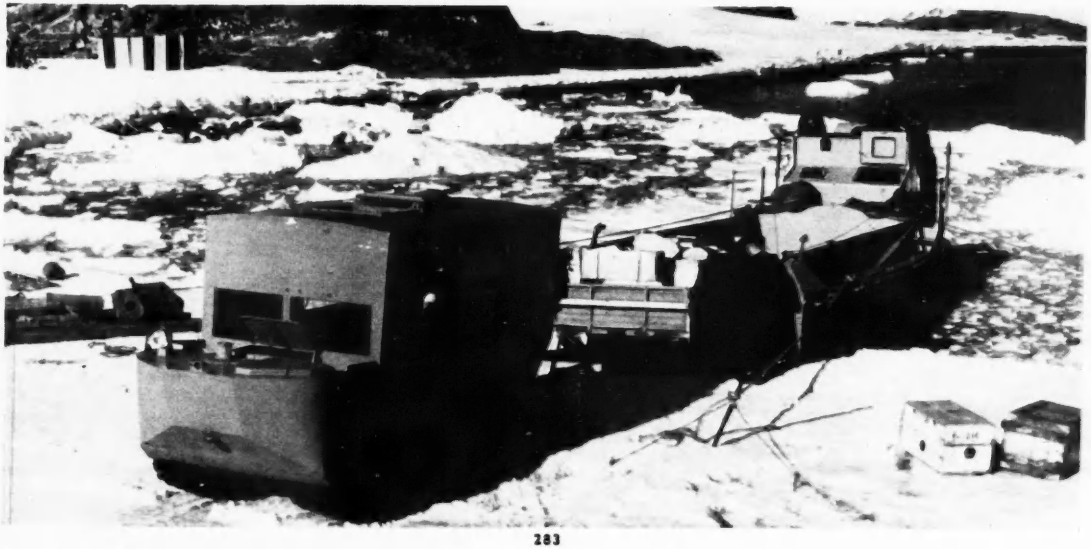


PLATE I (*left*). Three King Penguins (*Aptenodytes forsteri*) in the tussock grass at South Georgia.

PLATE II (*above*). The scene at the unloading point, with M.V. *Tottan* moored, and with the tractor ready to proceed inland.

(*By courtesy of The Royal Society Antarctic Expedition. Photographed by Mr. G. Hemmen. Enlarged from 35 mm. Kodachrome.*)

oceanographic campaign which a sub-committee of the French National Committee is directing under the chairmanship of l'Ingénieur-Général Gougenheim. During her first voyage, *Norsel* made a number of experiments with electro-magnetic apparatus for measuring currents and ocean swell. The oceanographic sub-committee has the use of seven ships from the French Navy and of six other vessels. Oceanographic research will be concentrated in the Mediterranean and East Atlantic regions, but two projects are beginning this year in the Indian Ocean. In addition, France will be carrying out oceanographic studies from nine stations including that in Adélie Land. These stations are located in Tahiti, Nouméa, Martinique, Kerguelen, Diego Suarez, the Marquise Islands, Dakar, and Casablanca.

Another of France's contributions is an attempt by the National Meteorological Office to determine the altitude of the hot layer of the upper atmosphere (about 50 kilometres). The explosion of heavy charges at Azay-le-Rideau will be recorded and analysed by five special stations to be set up in different parts of France. In two areas of the French Alps work will also be carried out in 1957 on the earth's crust. This will involve the use of two laboratories for seismic prospecting, four stations operating electro-magnetic seismographs, and six short-period electro-magnetic seismographs.

One of the most marked characteristics of the IGY will be the really effective contact between all stations participating in the work of measurement and observation. A series of World Days, similar to the International Days of the Polar Year of 1932–3, have been arranged, during which observations and measurements are to be intensified. Some of these World Days are fixed in advance and some are to be decided upon during the year as Special World Days. To effect co-ordination, and particularly to decide on the Special World Days, a world network with centres in the U.S.A., West Europe, Russia, and Japan, has been decided upon. The French Ionosphere Bureau, in liaison with The Hague and Darmstadt, will constitute the centre for West European and African stations. In particular the Paris Meudon and Pic du Midi observatories will contribute to the collection and generalisation of information about the sun and the solar corona.

The U.S. Antarctic Programme

Antarctic plans include the setting up of a scientific network of six stations during the IGY, and also an "air operations facility" for logistics support at McMurdo Sound. In selecting the positions for the stations, the National Committee was guided by (*a*) the general needs of the international programme, including co-ordination with other national plans in siting stations; (*b*) consideration of special geophysical problems requiring stations at specific bearings. The seven stations are: **Little America** (H.Q. station) 78° 16′S, 162° 28′W; **Byrd** Station (on the plateau of Marie Byrd Land) 80°S, 120°W; **Pole** Station 90°S; **Weddell** Station (on the Filchner Ice-Shelf of the Weddell Sea) 78°S, 50°W; **Knox** Station (off the coast of Knox Land) 66°S, 110°E; **Adare** Station (jointly with New Zealand) 72°S, 171°E; **Williams Air Operations Facility** (air-base and stores depot, 77° 51′S, 166° 37′E. The first- and last-named of these bases have already been established.

Besides acting as operational headquarters and conducting a major scientific programme Little America is the base for establishing and supplying Byrd Station to be set up in Jan. 1957 behind it on the plateau. There is access from the coast to the inland plateau at about the 4000 to 5000-foot elevation via the Prestrud Inlet; this should enable the bulk of supplies and equipment for Byrd to be brought in directly by ship to Little America. From there it is hoped to convey the stores 500 miles, first across part of the Ross Ice-Shelf, then up and well into the plateau by tractor trains (the tractors weigh 35 tons). Owing to difficulties met during this last season's reconnaissance, it is possible that Byrd may be supplied by airlift as was done for the icecap station of the British North Greenland Expedition of 1952–3, and as the Russians intend to establish their two inland stations in Antarctica, and the Americans their Pole Station.

Little America will be responsible for the IGY Antarctic Weather Central and its co-ordinated radio-communication systems to be operated for the benefit of all participating countries by the Americans at the request of CSAGI. The glaciological-seismic exploration of the entire Ross Ice-Shelf, which extends 450 miles north and south and 500 miles east and west, will also be carried out from this base during the two consecutive five-month Antarctic seasons ahead.

The establishment of Byrd Station will permit the study of a phenomenon revealed by the Scott Expedition's weather observations half a century ago. These records suggested the existence of pressure waves (or "surges") apparently spreading out from the neighbourhood of 80°S, 120°W. Since the Antarctic has the coldest atmosphere in the world,

FIG. 4. The *Glacier*, largest ice-breaker of the American IGY Antarctic base-establishing Task Force, 1955–6.
FIGS. 5 and 6. The scale of the American IGY work in the Antarctic can be seen from these two photographs showing four-engine aircraft and the large-size ships.

during winter and summer, and as the Ross Sea area also has the most persistent low-pressure belt found anywhere, the effect of Antarctica on world weather may be much greater proportionately than its size would warrant. Data from Byrd studied in conjunction with observations from other stations should show to what extent this is true.

Little America, Byrd, and Weddell stations near the edge of the maximum auroral zone, and the Pole and Knox stations within the zone, will provide a first-class network for studying the aurora australis. Byrd will also serve as the base for the second of three planned glaciological-seismic traverse parties; the third will operate from Weddell.

The Pole Station will offer a unique opportunity for research into glacial conditions and snow accumulation; also for studies of the effects on ionospheric properties of the sun's absence during the protracted Antarctic night. It will serve as the end station on the international pole-to-pole circles of meteorological posts. This station will assume special importance as an intermediate point or terminus for station-to-station and trans-continental traverses.

Knox Station, some 400 miles down the coast from the Russians' Mirny on Australian Antarctic territory, will fill an important gap in the international coverage of the continent. It should also be reasonably accessible by ship.

Adare Station on the tip of the continent, facing out where the Ross Sea joins the Pacific Ocean and directly across from New Zealand, is to be a co-operative American-New Zealand station. It will fulfil an extremely important role in the meteorological network of Antarctica. It will also operate a limited programme of work on aurora and airglow, the ionosphere, geomagnetism, and seismology. It will have an important function in air communications and operations, as it lies on the direct flight path from New Zealand to the already established Williams Air Operations Facility on the edge of the Ross Ice-Shelf.

Williams Air Operating Facility, situated at Hut Point on Ross Island at the conjunction of McMurdo Sound and the Ross Ice-Shelf, is to be the base for the airlift planned to establish the Pole Station during November and December of this year. The establishing by both ships and aircraft of this very considerable air station and stores depot was perhaps the largest and most formidable undertaking of this season's American naval expedition to the Antarctic ("Operation Deepfreeze I"). Meteorological work is an important part of the station's activities.

Lack of space prevents us from giving a complete account this month of the impressive and well-presented Antarctic programme, contained in the U.S. National Committee's April report. Here is a verbatim summary of the scientific work to be undertaken at the seven stations:

"All of the IGY scientific stations have programmes in auroral observations, geomagnetism, ionospheric physics, and meteorology. With the exception of Little America and Weddell stations, located on floating shelf-ice, these stations have also seismical programmes; and all but Adare Station, established on terrain which is snow-free in summer, have programmes in glaciology.

"In addition, cosmic-ray observations are planned for Little America Station and glaciology, gravity measurements, meteorology, and seismology programmes scheduled for the oversnow traverses. Shipboard observations include research programmes in the fields of cosmic rays, meteorology, oceanography and rocketry." During the summer of 1956–7 the Williams air base will conduct gravity measurements, in addition to this schedule. It should be mentioned that under the ionospheric programme the Americans are including research into the newly discovered "whistlers", or whistling atmospherics. This requires co-ordinated research with a conjugate geomagnetic observatory in the opposite hemisphere. Weddell, for instance, will be paired with a station in Labrador.

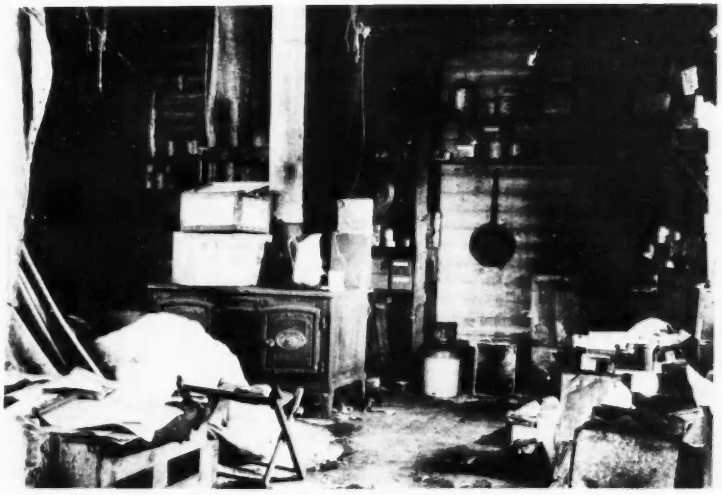
The rocket programme will use the "rockoon" (rocket and balloon), launched both from an ice-breaker at sea and also from the ice-shelf on the fringe of the continent. Dr. Milton W. Rosen, the American scientist associated with the development of rockets as a tool of scientific investigation, describes his early work in a recently published book, which is reviewed on another page (p. 298) of this month's DISCOVERY, and which provides admirable background reading to this field of IGY activity. Dr. Rosen is now head of the American Earth Satellite programme of IGY.

British Observer with "Deepfreeze I"

At the end of May, after six months abroad, a young naval navigating officer returned to this country. His voyage was packed with new professional incidents, more than can normally occur in six naval peacetime careers.

During those months Lt.-Cdr. M. J. N. Foster, R.N., official British observer with U.S. "Operation Deepfreeze I", had steamed from Norfolk, Virginia, to the New Zealand side of Antarctica and back; had made six distinct landfalls at points spaced round almost the entire Antarctic coastal perimeter; and had witnessed the setting up of the two huge American "springboard" bases for their seven-station Antarctic IGY programme. From the leading ship he had observed a fleet of four naval cargo ships burrow their way through 400 miles of pack-ice to land their cargoes, and he had watched the departure and return of ten long-distance reconnaissance flights using the McMurdo Sound ice as an airfield. Between them these aircraft have perhaps "sighted" much of the remaining Antarctic continent previously scheduled as "never yet seen by man".

But for an Englishman and a sailor in the Antarctic undoubtedly the most striking event was his visit by helicopter to Scott's and Shackleton's three camps along the shore of McMurdo Sound—camps whose solitude probably no one, and certainly no Englishman, has broken since those famous men walked out of them more than forty years ago. He found all the huts intact, and also much gear and provisions. In Scott's 1911 hut, in which Shackleton's party spent two years after being stranded by



A view of the interior of Scott's hut, in which Shackleton spent two winters, taken in 1956.

a sudden storm, a half-prepared meal lay on the table: "If I had been hungry I would have had a slice of the bread lying there." Relief had finally arrived after two years while the party was sitting down to dinner; they simply got straight up and went. It seems that if they were to come back tomorrow the next mouthful is waiting for them still.

"The Antarctic provides very effective deep-freeze," said Lt.-Cdr. Foster. "It was really very eerie."

The Voyage of the "Glacier"

Lt.-Cdr. M. J. N. Foster joined U.S.S. *Glacier* at the naval base at Norfolk, Virginia, last autumn. The Task Force appointed for "Operation Deepfreeze I" consisted of nine U.S. naval ships: the 8600-ton ice-breaker *Glacier* (the largest ice-breaker of the American IGY Antarctic base-establishing Task Force for the 1955–6 season); two *Wind*-class ice-breakers each of about 6500 tons; the 10,000-ton attack transport *Arneb*, in which sailed the officer in charge of the Task Force, Rear-Adm. George Dufek (retired); Admiral Byrd, in charge of the American Antarctic IGY programme, was in another attack transport, *Wyandot*. Besides these, there was the 10,000-ton naval auxiliary freighter *Greenville Victory*; the aviation-petrol tanker *Nespelen*; and two harbour-oilers, *YOG-70* and *-34*, which are now satisfactorily frozen in offshore at McMurdo Sound so that for the coming years they may be treated as static (land) oil-tanks. Petrol bowsers, aircraft, and Weasels can be driven up to them for refuelling. The craft comprising this Task Force also included eight large land-based aircraft, though only the two Skymasters and two Neptunes were used; four ship-borne De Havilland Otters fitted with ski-wheels, and seven large Sikorski helicopters also operated from the ships.

This fleet, which enabled the expedition to have substantial ice-breaking and air support at all stages, and also labour gangs for the crucial preliminaries of stores-hauling and building of a thousand men, is "the largest thing done in the Antarctic *ever*", in Lt.-Cdr. Foster's words. It set out from the United States in November of last year. The commissioning ceremony at Little America, their first task, took place on January 4, with three tents representing the camp. This now extends to twenty-one 50-foot huts, an "antenna farm", and an aircraft runway. Ten thousand tons of stores and instruments to equip both H.Q.-base and Byrd, were unloaded in under a month.

The Task Force carried, besides foreign observers including three New Zealanders, a detachment of newspaper- and cameramen, headed by the *New York Times*, *Life*, and a Walt Disney "Real Life" team. Three Japanese newspapermen were also of the party. The Associated Press was represented on the trip.

China's IGY Programme

Through the courtesy of Dr. A. M. Young, a biologist and an officer of the World Federation of Scientific Workers, who recently attended the "All-China Federation of Scientific Societies" in Peking, the following notes on the Chinese IGY contribution have reached us. Though small in relation to China's size, the programme is large in relation to the colossal tasks of industrialisation and expansion now proceeding. Moreover the leading observatory, Nanking, was wrecked during the war; the instruments have only recently been restored or renewed and the skeleton staff expanded from 8 to 64.

During the IGY, 21 stations are to be operated; 18 are already in existence, and one is scheduled to start work at Lhasa in Tibet at the end of 1956. The table gives their positions.

	Latitude N	Longitude E	Altitude metres
1. Manchuli	49° 35′	117° 26′	649
2. Chang-chun	43° 52′	125° 20′	216
3. Peking	40° 02′	116° 10′	43
4. Kashghar	39° 32′	76° 06′	—
5. Djassak	39° 14′	109° 52′	—
6. Lan-Chow	36° 05′	103° 40′	1506
7. Hsi-an	34° 15′	108° 55′	395
8. Nanking	32° 04′	118° 49′	68
9. Zikawei (Shanghai)	31° 19′	121° 02′	4
10. Zose (Shanghai)	31° 06′	121° 11′	100
11. I-chang	30° 42′	111° 05′	57
12. Wu-Han	30° 35′	114° 19′	28
13. Lhasa (Tibet)	29° 42′	91° 09′	3630
14. Chung-ching	29° 36′	106° 35′	291
15. Tung-chuan	26° 25′	103° 11′	3184
16. Kwei-lin	25° 15′	110° 10′	154
17. Kun-min	25° 03′	102° 41′	1922
18. Canton	23° 07′	113° 16′	9
19. Hai-Kou	20° 00′	110° 25′	3
20. Hsi-Sha	16° 51′	112° 21′	—
21. Nan-Sha	10° 23′	114° 21′	—

Meteorological research will be carried out at Stations 4, 5, 7, 11, 16, 19: and is proposed at Nos. 20 and 21. Ozone research is proposed at Station 12. Geomagnetic research is to be carried out at Stations 2, 3, 10, 18: and is proposed at Stations 6 and 13. Air glow research is proposed at Station 12, which is located in the very middle of China. Ionospheric research is to be carried out at Stations 1, 2, 3, 6, 10, 12, 14, 18, and 19. Solar activity research is being carried out at Stations 8, 10, 17: and is proposed at Station 12. Cosmic-ray research is carried out at Station 15: and is proposed at Stations 2, 3, 6, and 18. Longitude and latitude research will be undertaken at Station 9. Seismological research is being carried out at Stations 2, 7, 8, 10: and is proposed at Stations 3, 6, 13, 14, 17, and 18.

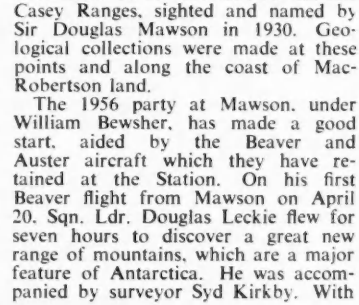
The Chairman of the Chinese IGY Committee is Coching Chu, Ph.D. (Harvard), meteorologist, geographer, and former President of Chekiang University. He is a Vice-President of the Chinese Academy of Sciences and Head of the Academy's Department of Biology, Geology, and Geography. He visited Britain in 1951 at the time of the Festival.

Australian Progress in Antarctic

Phillip Law, leader of the ANARE (Australian National Antarctic Research Expedition), reports that he returned to Australia on March 26 after a successful voyage in the *Kista Dan*. Most of Wilkes Land was photographed with the Expedition's Beaver aircraft. Landings from the *Kista Dan* were made at four points to which no ship had hitherto been able to penetrate. Comprehensive scientific observations were made during these landings and valuable depth-sounding data was accumulated during the voyage.

Exploration from Mawson Station is proceeding splendidly. In 1955 John Bechervaise and his men travelled 220 miles inland to explore the northern peaks of the Prince Charles Mountains, first seen the previous year by Robert Dovers. During 1955 the first visits were made to the Masson, David, and Casey Ranges, sighted and named by Sir Douglas Mawson in 1930. Geological collections were made at these points and along the coast of Mac-Robertson land.

The 1956 party at Mawson, under William Bewsher, has made a good start, aided by the Beaver and Auster aircraft which they have retained at the Station. On his first Beaver flight from Mawson on April 20, Sqn. Ldr. Douglas Leckie flew for seven hours to discover a great new range of mountains, which are a major feature of Antarctica. He was accompanied by surveyor Syd Kirkby. With



One of the two huge cosmic-ray telescopes at Mawson Station. The flat trays contain stacks of Geiger counters and the two bottom trays are separated by a thick lead absorber. The telescope, which is inclined, rotates 90° at the end of each hour. The cosmic-ray counts for each hour are automatically recorded.

an average height of 11,000 feet and several peaks over 13,000 feet above sea-level, this range begins about 150 miles SW of Mawson and extends first SW then SSW for more than 200 miles. Flights were also made during April and May to delineate the eastern and western extremities of the Prince Charles Mountains and to photograph the coast westward to Enderby Land.

The Mawson Station now comprises twenty-four huts and an aircraft hangar. The scientific work now proceeding includes observations of meteorology (with radiosonde and "rawin" observations), cosmic rays, geomagnetism, seismology, geology, glaciology, aurorae, and gravity. In February 1956 at Mawson important records were obtained from cosmic-ray and geomagnetic recorders of solar flare phenomena. Magnetic storm effects and ionospheric disturbances were associated with a great increase in cosmic ray intensity. The ANARE Station at Macquarie Island and duplicate apparatus maintained at the University of Tasmania also recorded the event.

Poles to go to Spitsbergen and Vietnam

On May 9, Polish scientists discussed Poland's contribution to the IGY at a conference in Warsaw. Prof. Rozycki gave a paper on the history and findings of pre-war Polish polar expeditions, and announced details of expeditions to be conducted during the coming IGY period. Prof. Rozycki, who took part in several Polish polar expeditions before the war, is now chairman of the Scientific Expeditions sub-committee of Poland's IGY national committee, the Geophysical Commission of the Polish Academy of Sciences.

Two IGY expeditions are planned by the Polish committee, one to tropical Vietnam and one to Arctic Spitsbergen. They are expected to last about eighteen months. In Vietnam, the work of the Polish expedition will centre on seismic observations. In Spitsbergen the Poles will conduct research in geophysics and glaciology, which will be important in developing their work on the quaternary formations of Poland itself.

PHYSICAL SOCIETY EXHIBITION 1956

C. L. BOLTZ

The Physical Society's annual exhibition of scientific instruments and apparatus serves as a first index of trends in physics research, a guide to the problems exciting the physicists and, by implication, the technologists of industry. It is a common experience, when seeing at a trade fair a new and shining piece of instrument-making, to find that a long time earlier its first plastic-and-wire model has been exuberantly demonstrated by a research physicist at the Physical Society Exhibition.

This year's show brought out the widespread interest in automation, both in performance and control, electronic simulation, extreme conditions of speed and temperature and pressure, colour television, and the possibilities not yet fully realised in new materials such as uncommon metals and semi-conducting crystals.

Automation was represented by Baird and Tatlock's automatic laboratory, the Analmatic, the Polychromator of Hilger and Watts, and the electronic control of a machine tool demonstrated by British Thomson-Houston, to say nothing of computers, both analogue and digital, exhibited in whole or part by a dozen different firms.

The Analmatic is a comparatively small but complete laboratory for the continuous and automatic quantitative analysis of a specific fluid. The reagents and operations and sequence are, of course, decided on beforehand. Once this is done the machine does the mixing and filtering and separating until the amount of a suspected diluent or "impurity" is shown on an instrument. The Analmatic goes on doing this without attention except maintenance. Though it is not new in the strictest sense—one was shown at the British Instrument Industries Exhibition last year—it is new to the Physical Society and no doubt to most of this year's visitors.

The Polychromator is an elaborate spectrographic analyser. A mixture of up to thirty different metals can be analysed in a few minutes with the quantity of each automatically recorded. A spark creates the conditions for spectral-line luminosity and the total output is analysed by a three-metre diffraction grating. In the machine-tool control BTH use electric generators that stop the motors when a pre-arranged position is reached. It will position the work or the tool to an accuracy of half a tenth of a thousandth of an inch.

Simulation, for example, of traffic conditions in the air, is increasingly used. The idea is to make electronic circuits behave analogously to events that it would be inconvenient and outrageously expensive to produce in reality. Elliott Brothers were showing a "homing" simulator, presumably for use with guided-missile research. It is, in fact, a computer that solves differential equations. GEC had a simulator for multi-channel telephone circuits, while the Atomic Energy Research Establishment showed a system of coupled electronic circuits to simulate the performance of a nuclear reactor. The trainee nuclear engineer and the research scientist can thus learn the performance of a reactor under a number of different conditions. Standard Telephones and Cables showed a radar simulator for the training of RAF operators.

Extreme physical conditions have brought problems that call for special instrumentation and design. The capsulation of miniature electronic circuits in modern synthetic resin as a protection against heat and moisture and shock is one resulting technique demonstrated at the exhibition. Extreme speed, with its stresses on machine and man, calls for small instruments that will be robust and accurate in the measurement of strain and acceleration. A number of new strain gauges and accelerometers were shown. Even the softest of raindrops becomes a damaging missile on the window of a jet aircraft. The Royal Aircraft Establishment has therefore developed a new apparatus in which a drop of water is hit by a target at any chosen speed so that the effects can be thoroughly analysed.

The Colour Group of the Physical Society presented a complete course for the layman in the principles of colour television. People passing through this show at the rate of 150 an hour were able to see remarkable

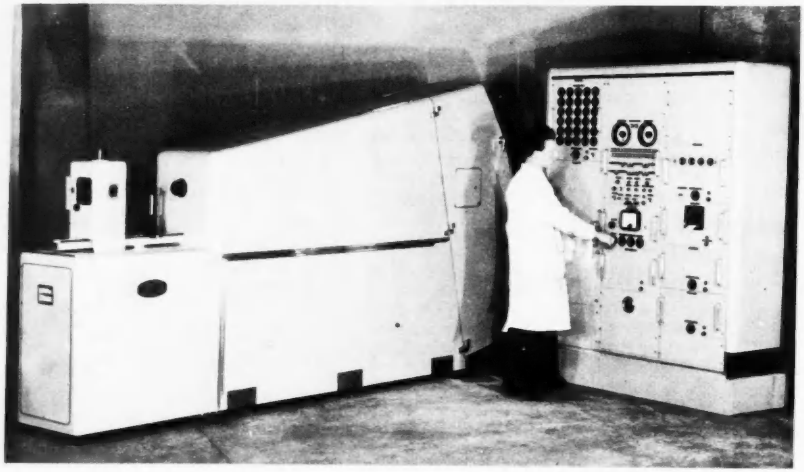


FIG. 1. The large quartz polychromator recently shown by Hilger and Watts at the Physical Society Exhibition. Full details are given in *Hilger Journal*, vol. 2, no. 4, May 1956.

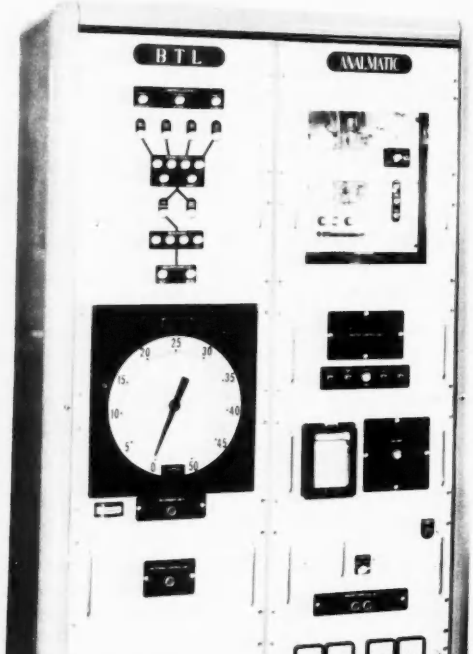


FIG. 2. Demonstration of Automatic Laboratory, which takes a sample, carries out various chemical operations, and measures pH as well as colour and intensity.

demonstrations that led from simple three-colour mixing to the subtleties of human perception. (Is it generally known, for instance, that while a person will be very critical about the definition of a black-and-white picture he will tolerate a wide range of indefiniteness in the borders of added colours?) Many firms co-operated with the Group's chairman and his colleagues to make this demonstration the most complete and convincing of the exhibition. Colour television also came up again in one of three evening lectures.

Semi-conducting materials and their applications figured in more than twenty exhibits. General Electric showed a germanium diode suitable for rectifying currents of the order of 300 amperes and Mullard showed high-speed switches and high-frequency oscillators based on semi-conductors. Both these companies have been very interested in semi-conductors for some years.

The most interesting of all the exhibits in this field, to one visitor at least, was that of the Services Electronics Research Laboratory, part of the Admiralty Research Establishment. For some time physicists here have been interested in the compound indium antimonide and now that they can make it satisfactorily they have developed a number of fascinating applications. Indium antimonide is an artificially made semiconductor in which the electron mobility is nearly twenty times that of germanium. One consequence of this is that the Hall effect—the production of a potential difference across a conductor by means of a magnetic field—is so pronounced that no amplifiers are needed and the power produced can be made to operate mechanisms. The exhibit showed a small crystal of indium antimonide acting as a navigation compass, a magnetometer, a microphone, an infra-red photocell, an amplifier, a valve to conduct oscillators only one way, and even as an automatic control of trains, an application in which British Railways is very interested.

Though these general trends are the chief points of interest for the visitor who is not himself a practising physicist, the exhibition also has its original function of

showing apparatus to people who may want to use it. Many scientists and teachers come to the Physical Society Exhibition on purpose to see what apparatus is available for their own use. This is a commercial aspect that no ruling of the exhibition authorities can undermine, for a physics teacher or researcher definitely wants to know the price of a piece of apparatus and its delivery time. The layman, anxious to get all the interest he can from demonstrations and lectures, may regret this commerce; and the authorities, by rightly insisting on the newness of any apparatus shown, can try to restrict it, but some of it is unavoidable. So it looks as if the pattern of the Physical Society Exhibition for years to come must be this odd blend of commercial instrument display with demonstrations of entirely new research.

THE CINE CAMERA AS A RESEARCH INSTRUMENT

An International Research Conference, reported by members of the British Delegation

The use of the cine camera as a research tool is as old as cinematography itself. Indeed it was a desire to investigate the details of animal locomotion that stimulated the invention, although soon this strictly scientific purpose was completely overshadowed by the exploitation of the movie camera as a method of propagating otherwise expensive forms of entertainment cheaply. This exploitation led to the development of cinematic forms of artistic presentation, to a grammar of cinema aesthetics, and all the esoteric theories with which art forms are enveloped by the intellectuals. The original intellectual purpose of the cine camera—scientific research—was thus smothered, for it became emotionally difficult for scientists, unaware of the strict purpose and possibilities of the cine camera, to consider the claims of its exponents seriously.

This state of affairs is at last tending to be corrected. Recently the first modern English publication on the use of the cine camera as a research tool was published,* it contains nearly 1500 references. At Göttingen in the middle of April the Research Films Section of the International Scientific Film Association held its fourth annual meeting. Nearly two hundred delegates from nineteen countries, including India, Japan, and Australia, attended the meeting. There were more British delegates than have so far ever attended one of the overseas meetings. About eighty representatives from European *Technische Hochschulen* were present (these are the equivalent of Universities of Technology, of which so far only one exists in the British Empire, the New South Wales University of Technology in Australia). Each one of these Universities appoints a research and teaching film consultant at professorial level: each is an expert in applied cinematography in addition to his academic qualifications.

Practically all the films shown by those attending from Western Germany were made by the Institut für Wissenschaftlichen Film, Göttingen, Western Germany. The scientists gathered in Göttingen were to speak not of their discoveries, but of the cinematic methods they had developed to make discoveries. The chief emphasis this year was on animal behaviour and locomotion. Many small animals and fish live their active life in near or total darkness, and are relatively immobile in bright light. By the use of infra-red illumination their mating and fighting habits have been recorded and studied. The pattern of locomotion of four-legged animals is still only slightly known; new studies on police-dogs, which have learnt to obey orders, have been recorded with the camera running at high speed, and then the pattern of movement of their limbs has been plotted graphically by analysing the film frame by frame. A new projector was demonstrated in which two films—of two separate animals, for example—can be run alternately at will and thus studied comparatively. The learning behaviour of young carnivores faced with their first live prey was fascinating, as was the pecking behaviour of young woodpeckers, again recorded by infra-red light. Several studies were presented independently of the action of the tongue in animals and birds which eat ants or wood-boring insects. In these the tongue movements are so fast that a high-speed camera, running at several thousand pictures a second, was needed to reveal the five-fold increase in length of the tongue.

Another relatively new technique is the x-ray image intensifier. Although only a few models have as yet been made commercially available, the wide field of applications is already apparent. Television techniques on the other hand were not reported at this meeting, although well known in some fields, for example in furnace and nucleo-thermal work. Indeed it may fairly be said that at this Congress the emphasis was deliberately on biological and academic applications: industry was scarcely mentioned. Although this was partly chance, it does indicate that much of the use of the cine-camera as a research tool in industry is secret work, or at least is treated as such and therefore not available at international meetings. It seems a pity, but is probably unavoidable; for example, it was revealed at one recent meeting that nearly all the British car and cycle manufacturers had simultaneously, independently, and secretly, investigated the phenomenon of valve rebound; they had all turned to the high-speed cine camera for assistance, had all come to much the same solution, and had all prepared in secret their independent sales promotion for the same exhibition.

* "Research Films in Biology, Anthropology, Psychology and Medicine", by A. R. Michaelis. New York, 1956. London Representatives: Academic Books Ltd., 129 Queensway, London, W.2. Price £4 4*s*. 0*d*.

ATOMIC WEAPONS, GUIDED MISSILES, AND THE FUTURE OF WAR

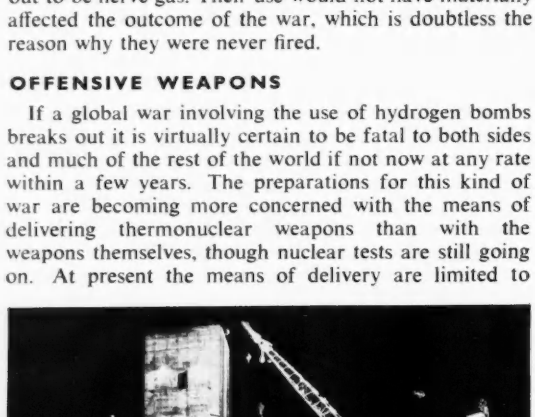
BY A MILITARY CORRESPONDENT

America and Russia are locked in a race to be first to perfect an intercontinental ballistic missile capable of carrying a thermonuclear warhead 5000 miles and travelling most of the way above the earth's atmosphere. This search for the so-called "ultimate weapon" is one extreme in the modern scale of war. At the other extreme we have British troops in Cyprus using shields more rudimentary than those used by the Romans to ward off Cypriot brickbats. In Algeria French troops are using anything from mules to helicopters to seek out the terrorists.

Most if not all the military weapons developed during the history of the human race have been used in war at some time, however horrific their effects. Neither side used gas in the last war, but it would be unwise to draw any moral from that abstinence when we remember that in the much smaller Korean War the Allies used napalm bombs, an equally beastly method of destruction. If gas was not used in the last war it was not for lack of gas weapons: during the crossing of the Rhine in 1944 German shells were discovered filled with an unknown chemical agent which on analysis turned out to be nerve gas. Their use would not have materially affected the outcome of the war, which is doubtless the reason why they were never fired.

OFFENSIVE WEAPONS

If a global war involving the use of hydrogen bombs breaks out it is virtually certain to be fatal to both sides and much of the rest of the world if not now at any rate within a few years. The preparations for this kind of war are becoming more concerned with the means of delivering thermonuclear weapons than with the weapons themselves, though nuclear tests are still going on. At present the means of delivery are limited to manned aircraft—in the West to the United States Strategic Air Command of B47 and B52 bombers and the RAF's V-bombers.



The *Redstone* rocket in position for firing from its tower.
(By courtesy, U.S. Information Service, American Embassy, London.)

There is at present no antidote to the ballistic missile. The only defence is retaliatory capacity based on the same means of delivery. America is therefore going all out to produce a long-range missile. Her main hope is the *Atlas* rocket-powered missile, which is planned to travel at 8000 miles per hour. Other long-range American missiles are the *Snark*, which is really a pilotless bomber powered by a jet engine and which recently flew 2000 miles across the Caribbean, and the *Navaho*, a ramjet missile which uses stellar navigation in flight. In its present form the *Snark* is virtually obsolete because it cannot fly higher than about 60,000 feet and its speed is subsonic, which makes it a fairly easy target for air defences.

In 1954 it was agreed during Anglo-American talks on guided missiles that America should concentrate on developing an inter-continental ballistic missile and Britain on developing an intermediate missile with a range of about 1500 miles. As this year's British Statement on Defence said, "Particular emphasis is being placed on the development of the ballistic rocket as a deterrent to aggression." Since 1954, however, America has begun two projects in the same field, an air force project and a joint army and navy one.

There are enormous technical problems in the development of both types of missile. The greatest problem is not range but accuracy. The present standard of accuracy for missiles is 0·2%, which is good enough for tactical missiles such as the *Corporal*, which has a range of about 50 miles. With a missile travelling 5000 miles, however, this standard would allow for an error of up to 10 miles, which is not a practical answer even when the missile has a hydrogen warhead. Unless long-range missiles can be made to carry much larger warheads than at present seems possible the problem of accuracy is likely to remain unsolved for some years yet.

There have been statements in the American Press suggesting that missile warfare is just around the corner and the manned aircraft on the verge of being superseded. Senator Stuart Symington has said he "knows for sure" that the Russians have tested an intercontinental missile that can travel farther than any so far tried out by the United States. When asked about this President Eisenhower said that the whole discussion of guided missiles was blurred by failure to distinguish between missiles whose guidance could be initially controlled and those that depend on correction in flight. What the President was obviously getting at was the problem of accuracy. Until the missile develops an accuracy as great in proportion to the size of its warhead as that of the bomb dropped from a manned

aircraft it cannot supersede the bomber. Even given this accuracy, it is extremely doubtful whether the missile will in fact wholly supersede the bomber. Would any nation, however much bent on aggression, rely solely on the calculations of a machine for defeating its enemy when the penalty for miscalculation would be instant retaliation and annihilation? It is also worth remembering that no nation has yet fired a guided weapon with an atomic warhead.

DEFENSIVE WEAPONS

For the next ten years or so the manned bomber is likely to remain the basis of the Western policy of nuclear deterrence. Parallel with the development of offensive missiles runs the development of defensive guided missiles. Dr. Walter Dornberger, who was head of the German rocket development centre at Peenemünde during the last war, said recently in America, where he is now a guided missile specialist for the Bell Aircraft Company, that within five or six years missiles will provide defence against all types of aircraft or missiles flying at less than 3000 miles an hour.

The principal cities of America are already ringed by batteries equipped with the *Nike* anti-aircraft missile. This seems to be mainly in the interests of morale since the *Nike* has a very short range. It is generally thought that if an aircraft carrying a hydrogen bomb is hit the bomb will go off; therefore, unless the aircraft is hit when it is over sea the resulting explosion in the air will still be capable of doing great damage on the ground.

Because of this danger British research has aimed at developing a defensive missile with a range great enough to enable it to cope with all possible targets from two or three launching sites only. It has to be recognised, however, that although 100% air defence is theoretically possible, it is at the moment and for the foreseeable future quite impracticable economically. It is doubtful whether any nation can realistically expect its air defences to do more than compel an enemy to encumber his bombers with complicated electronic defensive equipment.

THE OFFENCE-DEFENCE BALANCE

If this is the likely pattern of the preparations for nuclear war during the next few years it is reasonable to guess that offence will keep its present advantage over defence. This being so, it is inconceivable that any nation could knock out another nation by nuclear war without being reduced to ruins itself. When there are no fruits of victory to be had, war loses its point. If we rule out the possibility of deliberate nuclear aggression, there remains the possibility of nuclear war by accident —of some conventional aggression leading by accident to the exchange of nuclear bombs. Again it looks as if the unprecedented destructive powers of nuclear weapons are the strongest possible check against miscalculations of this kind.

The corollary of this view is that the Western policy of trying to deter conventional types of aggression by nuclear superiority will cease to be valid as soon as Russia is in a position to retaliate effectively in kind—as soon, that is, as she has a strategic bomber force capable of striking at America. The Russian TU 104 in its bomber form will not have enough range to hit the critical central parts of the United States, but the development of a bomber that can is only a matter of time.

Let us now examine our preparations for limited war involving the use of tactical atomic weapons. The ground defence of Western Europe is based on the use of these weapons. The British Army of the Rhine manœuvres in Germany last autumn predicated atomic weapons ranging in power from 2 to 100 kilotons. The smaller weapons can be delivered by the American 280-millimetre atomic cannon, the larger by rockets, and all by aircraft. To obtain the maximum effect these weapons would be fired to burst in the air and would cause no radioactivity on the ground, so that troops could follow up to exploit the effects immediately, as they have done in American atomic training at Nevada.

The Americans are developing a whole range of guided missiles for the delivery of these tactical weapons, including:

(i) The *Redstone* ground-to-ground missile with a range of 300 miles, which has been developed by scientists working under Dr. Wernher von Braun, the German designer of the V2 rocket. In March this year the U.S. Army formed its first guided missile battalion equipped with the *Redstone*. (See Illustration.)

(ii) The Martin *Matador* ground-to-ground missile which is launched by a rocket and is about the same size and weight as a jet fighter aircraft. It is the U.S. Air Force's first tactical operational weapon to be stationed in Europe. In effect it is an expendable aircraft, and recalls the kamikaze, or suicide, Japanese aircraft tactics of the last war in which the pilot aimed his aircraft at the target.

(iii) The *Corporal* supersonic ground-to-ground guided missile, which has a range of about 50 miles. *Corporal* missile battalions are stationed in Europe, and the *Corporal* is being bought for operational use by the British Army.

(iv) The *Honest John* free-flight rocket, which has a range of about 20 miles, or roughly the same as that of the American 280-millimetre atomic cannon. While probably less accurate than the cannon, the rocket can carry a much larger warhead.

The characteristic of all these weapons is that they seek to turn a weapon of mass destruction—the atomic bomb of Nagasaki and Hiroshima—into a precise tactical weapon for use against purely military formations. There is little doubt that chemical warfare could be used in a similar way. Blister gas, for instance, could be used to contaminate ground and thus deny it to an enemy. Some of the modern forms of nerve gases might also be used, though countries like Britain who are signatories of the Geneva Convention have promised not to do so.

AGRICOLA AND HIS "DE RE METALLICA"

THE FIRST MODERN CLASSIC OF TECHNOLOGY

J. H. S. GREEN, Ph.D., A.R.I.C.

The early 16th century saw a number of activities which marked it off from the Middle Ages and foreshadowed the great advances which were to come more than a hundred years later. Some craftsmen acquired a certain amount of "scholarly" knowledge, and at the same time some scholars became interested in the practice of the craftsmen. In March 1556, 400 years ago this year, was published *De Re Metallica* (*Concerning Metals*), which has been called "the first modern classic of technology". It was the greatest mining treatise of its time and remained the standard work for some two hundred years. Newton studied it when he was investigating the chemistry of metals. Black, in his lectures (1803) referred to it for details of the methods of washing and reducing ores. Even during the 18th century mining methods were essentially those of two hundred years earlier, and some of the winding apparatus and water-wheels described in this book were still in use. The first translation into English was made by Herbert Clark Hoover and his wife, Lou Henry Hoover, while they were staying at the Red House, Kensington, London, before 1914. Later he was elected President of the United States and occupied the White House, Washington. His translation first appeared in *The Mining Magazine*, London, in 1912, and an unabridged edition was published by Dover Publications Inc., New York, in 1950, with all 289 of the original 16th-century drawings, three appendices by President Hoover, a biographical and historical introduction, Agricola's original preface, and a facsimile of the 1556 title page and four facsimile pages of the original Latin text. One appendix gives a full list of Greek, Roman, and medieval authors in mining or metallurgy whose works were available to Agricola.

GEORGII AGRICOLAE
KEMPNICENSIS MEDICI AC
PHILOSOPHI CLARISS.

DE RE METALLICA
LIBRI XII.

QUIBUS OFFICIA, INSTRUMENTA,
MACHINÆ, AC OMNIA DENIQUE AD METALLICAM SPECTANTIA, NON MODO LUCULENTISSIME
describuntur: sed & per effigies, suis locis insertas, adjunctis Latinis, Germanicisque appellationibus, ita ob oculos ponuntur, ut clarius tradi non possint.

Quibus accesserunt hac ultimâ editione, Tractatus quidam argumenti, ab eodem conscripti, sequentes.

De Animantibus Subterraneis. Lib. I.
De Ortu & Cautis Subterraneorum. Lib. V.
De Natura eorum quæ effluunt ex Terra. Lib. IV.
De Natura Fossilium. Lib. X.
De Veteribus & Novis Metallis. Lib. II.
Bermannus sive de Re Metallica, Dialogus. Lib. I.

Cum Indicibus diversis, quicquid in Opere tractatum est, pulchrè demonstrantibus.

BASILEÆ,
Sumptibus & Typis EMANUELIS KÖNIG.
ANNO M. DC. LVII.

FIG. 1. Title page of Book 12 of Emanuel König's edition of the *De Re Metallica*, 1657.

The author of *De Re Metallica* was George Bauer, usually known by the Latinised equivalent, Agricola. He was a scholar though certainly no scholastic. Born in Saxony in 1494, his earliest distinction was as a linguist —he learnt Greek from an Englishman—but at about thirty years of age he became interested in medicine and in 1525 was partly responsible for a Greek edition of the works of Galen (A.D. 131–201) the anatomist and physiologist. He studied medicine in Italy and qualified as a Doctor of Medicine. In 1527 he became Town Physician at Joachimsthal, the centre of the mines which had been opened up about ten years earlier; although now famous for uranium, the district then produced much silver and was at that time the greatest mining area in central Europe. Agricola was extremely interested in the first-hand investigation of mining and all related subjects. Being a widely educated man, he was sent by the Elector of Saxony on political missions. In spite of his being a Catholic, he was several times elected Burgomaster of the strongly Protestant Chemnitz, to which he moved from Joachimsthal. This was another mining centre, and he lived there until his death in 1555. Apparently *De Re Metallica* was completed in 1550 after many years' work; though thirty years before he had produced a smaller book on mining (*Bermannus*) which had an introduction by Erasmus, with whom Agricola corresponded.

AGRICOLA'S WORK

De Re Metallica deals with almost every aspect of the mining industry and related procedures of metallurgy. It contains long descriptions of purely engineering matters, such as the tools and machines used. (Mining played an important part in stimulating the invention of new mechanical appliances—hauling machines, water pumps and ventilating devices, for example.) Almost all these were worked by men and animals, and there is even described a water-raising apparatus which required ninety-six horses.

Agricola begins by telling us that he has been at pains either to see for himself what he describes, or to be sure of his authorities. He states: "I have omitted all those things which I have not myself seen, or have not read or

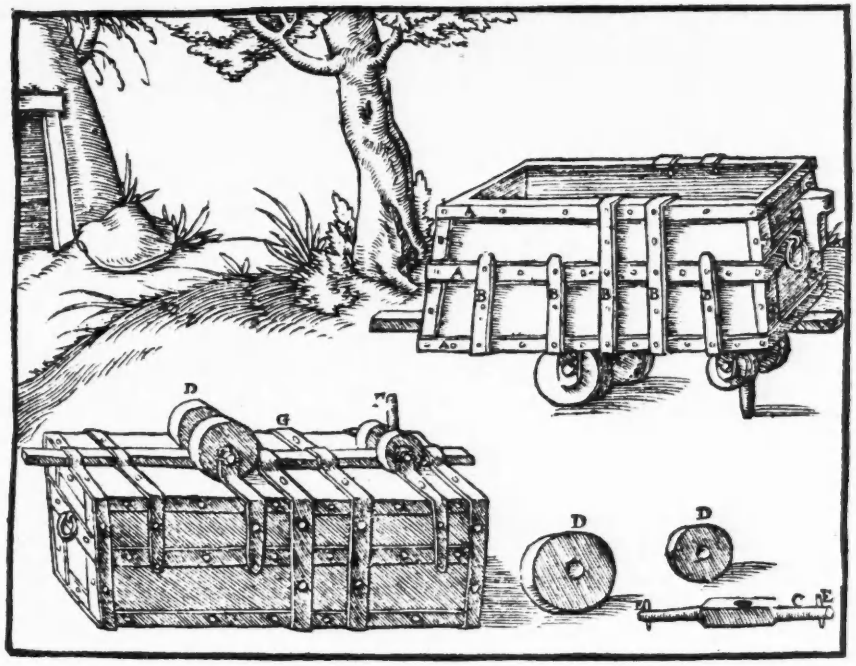


FIG. 2. Trucks for carrying metals, showing construction.

heard of from persons upon whom I can rely. That which I have neither seen, nor carefully considered after reading or hearing of, I have not written about. . . ." The charming woodcuts are perhaps the most attractive feature of the work. For, as he says: "I have devoted much labour and care, and have even gone to some expense upon it; for with regard to the veins, tools, vessels, sluices, machines and furnaces, I have not only described them, but have hired illustrators to delineate their forms. . . ."

He deals in some detail with the successive stages by which ores are obtained, assayed, prepared and smelted, and with the purification of the precious metals. Each stage is described in detail. For example, in connexion with obtaining the ores, he discusses the principles of mining, procedures in surveying, including the instruments used, the methods of digging and the various ores to be found. His description of the arrangement of seventeen different strata which he had observed in the Hartz mountains is a classic of geology and has been called the "first contribution to stratigraphic geology". He described the sorting, crushing, grinding, washing and roasting of the ore, and the processes of preparing it for smelting.

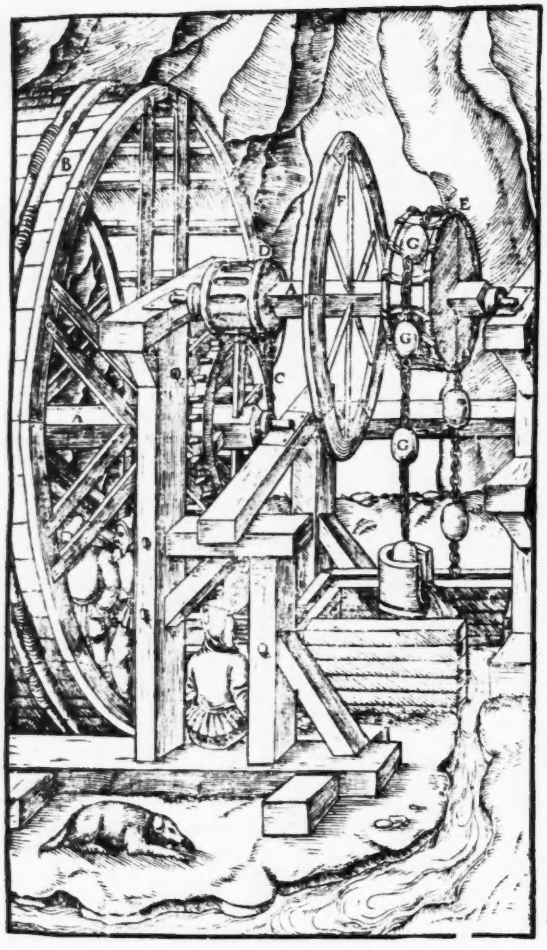
In Agricola's metallurgical descriptions there is much that we should regard as parts of industrial chemistry, and the methods of assaying are the beginnings of chemical analysis. They involved the use of small furnaces, crucibles, and balances, all of which are described. Original details are given for the assaying of bismuth, mercury, iron, and tin. There is an account of the refining of silver and of gold, including the use of mercury for recovering the latter. Mineral acids, or mixtures of them, which Agricola called *aqua valens* and which were prepared by distilling vitriol with salt and saltpetre, are described for separating gold and silver.

In the last part of the book Agricola lists the sources and preparation of what he called "solidified juices"—including salt, potash and soda, alum, sulphur, bitumen, saltpetre, vitriol, and glass. This section is not perhaps entirely relevant to the rest of the work, but in spite of some errors does give an account of the beginnings of chemical manufacture. As Professor John Read has said: "Agricola's clear and practical treatment of his special field of chemistry paved the way for Libavius' *Alchymia*, which appeared in 1595 . . . the first work which has a claim to be considered as a text-book of chemistry." (*Prelude to Chemistry*, 1936, p. 80.)

Agricola discusses a number of problems relevant to mining, including administration and the economics of the industry, with some advice to potential investors against fraud: ". . . a prudent owner, before he buys shares, ought to go to the mine and carefully examine the nature of the vein . . ." He also gives one of the first accounts of the use of the divining rod, the value of which he discounted. His medical background shows itself when he mentions: "the ailments and accidents of miners, and of the methods by which they can guard against these."

The book is not overburdened with theoretical speculation, but Agricola was, after all, a scholar, and he does give the view that the metals are generated from the Aristotelian elements, earth and water. He also believed that metals are re-formed in worked-out veins. (This view was held even in the early nineteenth century, for example by Buffon and by Fourcroy.)

De Re Metallica is essentially a work on technology



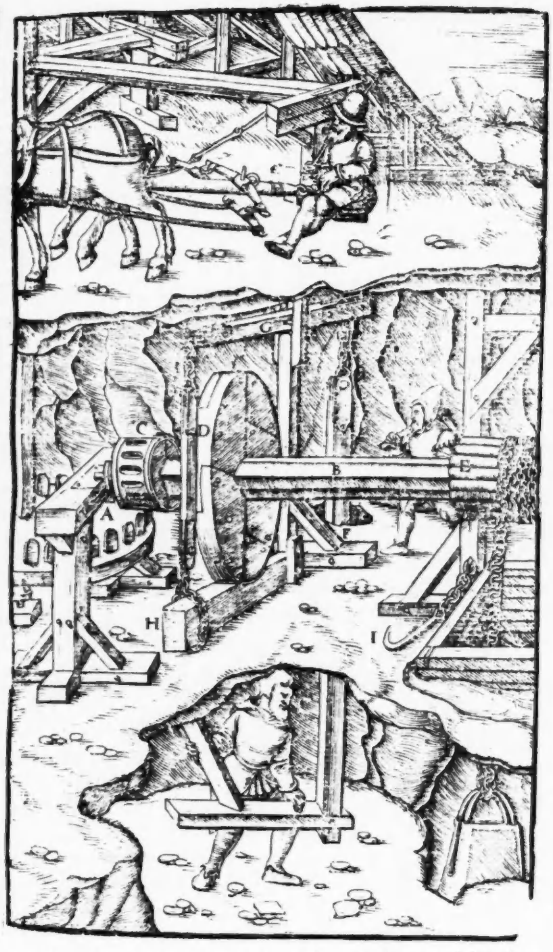


FIG. 3 (*left*). A chain pump worked by treadmill. FIG. 4 (*right*). A horse whim. Note the hand brake worked from the bottom of the mine.

rather than science, and it is of course impossible to know how much of it is original. Agricola's position as a scientist rests more surely on his geological work. Besides those mentioned, he wrote five other books dealing with geological subjects. *De Ortu et Causis Subterraneorum*, 1546, was the first work on physical geology. *De Natura Fossilium* dealt with mineralogy, and the geologist Werner called Agricola the "Father of Mineralogy." Agricola was highly thought of by many of the founders of experimental science. William Gilbert in his *De Magnete*, 1600, considered him to be "outstanding in science", and Boyle called him "the most classick author we have about mines".

The significance of *De Re Metallica* in the history of science and in particular of chemistry, is not small. It not only records much that we should now call industrial chemistry and which provided the materials for the later chemists to work with in their laboratories; it also summarised many basic chemical facts, procedures, and reactions in straightforward language free from the mysticism of the alchemists. It thus belonged to the earliest stages of the Scientific Revolution, a characteristic of which was a preference for recording experience rather than for original, constructive thought. Systematisation, and elaboration of the theoretical basis of his work was to come much later. To quote Professor Read again: "writers of the type of . . . Agricola made the road along which later generations were able to pass from the cribbed and cabined confines of alchemy into the spacious domains of chemistry."

REFERENCES

Adams, F. D., "The Birth and Development of the Geological Sciences", New York, 1954.

Eyles, J. M., "Georgius Agricola", *Nature*, 1955, vol. 176, p. 949.

Wolf, A., "A History of Science, Technology and Philosophy in the Sixteenth and Seventeenth Centuries", London, 1950.

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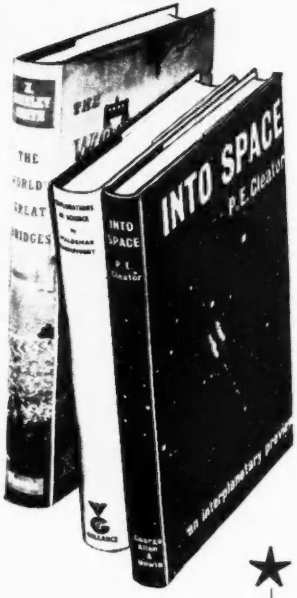

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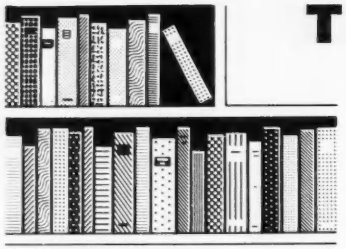

Physiological Acoustics

By E. G. Wever and M. Lawrence (*U.S.A., Princeton University Press: London, Geoffrey Cumberlege, 1954, xii+454 pp., 80s.*)

This book takes the reader to a frontier of science at which exact experimental knowledge and intuitive extrapolation give way to speculation and inspire the imagination concerning the remarkable world within us. In no field of inquiry is the gap between achievement and the attainable more tantalising than in the study of the special senses, a subject at once familiar in some degree to all yet still eluding—even in some essentials—the combined advance of medical and physical science. Nineteenth-century optimism in discovery by way of mechanical models has been shattered, and with it the elegant but faulty theories of Helmholtz regarding the mechanism of hearing, with its neat array of tuned resonators. It was soon discovered that nature had contrived a more recondite principle. Helmholtz's conjectures were largely based on anatomy and the evidence of what would today be termed "psycho-acoustical" data, for example, observations of pitch and loudness discrimination. Modern studies continue to draw on these sources, but in addition they are powerfully aided by new techniques employing electronics applied to anaesthetised animals. This has enabled the purely acoustic actions of the ear—a proper study of the physicist—to be investigated separately from the later processes which are the responsibility of the neurophysiologist and the psychologist.

The publication of this book by two of the leading workers in the first of these fields is a notable event. Wever was among the first to discover and exploit as a research tool the cochlear microphonic effect, or Wever-Bray effect as it is usually called. Many have followed the same technique, but perhaps none so brilliantly as the originators and their co-workers, as a means for tracing the path of sound and its distortions through the complexities of the hearing mechanism. Paradoxically it is still uncertain whether the microphonic potentials which they observe for this purpose play any direct part in the process of hearing or are merely a by-product.

The authors consider systematically each step in the transmission of a sound wave from the eardrum to the final point within the organ of Corti at which the acoustic pathway ends. At each stage a short historical account is given, and alternative theories are reviewed and often demolished although sometimes by rather delicately balanced arguments. The style is authoritative and persuasive. The logical sequence, and the authors' forthright statements of their own standpoint on the controversial problems discussed, conduct the non-specialist through the tangle of uncertainties and alternatives, and succeed in giving the impression that a satisfactory and coherent theory has now been established. There is scope for a companion volume written with equal conviction on the processes beyond the point of junction of the acoustic and neural domains, for it is at this point that a solution of the central problems of hearing may be found. Among these is the mechanism by which the dynamic range of audible sounds—10^{14} to 1 in terms of energy—is compressed into the much narrower range of numbers corresponding to sensation. Perhaps the leading question, however, is how to reconcile the experimental fact of fine pitch discrimination with the blurred patterns of action in the cochlea revealed by the Wever-Bray potentials. Some form of "sharpening-up" process, it seems, must be invoked, but it is doubtful if any of the ingenious theories so far proposed by various workers can explain it. Some of these theories are touched on by the authors. They do not, however, make any reference to what is perhaps the most credible and well-developed proposals in support of the place-principle of pitch localisation along the cochlea, namely the work of Pumphrey and Gold.

An interesting and unexplained phenomenon well known in applied acoustics is the apparent rise of threshold level (or reduction of loudness) of a sound heard through an earphone compared with the same sound heard in a free field. By "same sound" we mean identical as measured at the eardrum. The origin of this effect is generally thought to be peripheral to the cochlea and so falls within the scope of this book. The authors' suggestion that it is due to an alteration in the effective impedance of the ear lacks conviction and seems to do little more than restate the problem.

The book contains an interesting section on clinical applications, in particular the interpretation of successes and failures of the fenestration operation for otosclerosis. There is a useful table of anatomical dimensions and some good plates. The introductory chapter on the physical attributes and measurement of sound will commend itself to the reader who is not primarily concerned with acoustics. The value of the book as a record of over twenty years of research and notable achievements in this specialised field will easily be recognised, as well as its convenience as a work of reference.

D. W. ROBINSON

Pelican in the Wilderness

By F. Fraser Darling (*London, George Allen and Unwin, 1956, 380 pp., 25s.*)

In these days agriculturists, pedologists, and biologists are faced with the serious problem of misuse of land and its resources. How can man continue to live on the planet without destroying still more of its complex life? How can there be biological restoration when destruction has taken place? Though Dr. Fraser Darling does not suggest how this destruction of the earth's resources can be brought to people's attention, his fear and abhorrence of it runs through the pages of this book. Emphasis is laid upon reforestation, upon the prevention of overgrazing, and upon measures to restore vegetation by, for instance, the simple principle of constant movement. The influence of men on vegetation is discussed, and also what happens to mankind after the destruction of forests and meadows has taken place. Botanists already accept that many deserts in Africa and Asia came into existence as a result of overgrazing and overburning. Therefore the most important idea in this book is the emphasis which the author puts on a more detailed study of human ecology. Dr. Darling's ideas and warnings are interwoven with a very well-written narrative of his trips across the United States, Mexico, and Alaska. The author's deep love and sorrow, not for nature only, but also for his fellow-men, makes this a book worth reading by scientist and non-scientist alike.

P. VAN ROYEN

The Viking Rocket Story

By Milton W. Rosen (*London, Faber and Faber, 1956, 248 pp., 21s.*)

Dr. Rosen is not unknown in Britain. At the British Association meeting in September 1955 in Bristol he delivered an excellent paper on the subject of rocket research and its future implications. Few of those who listened to him then were aware of the details of the work he had carried out during the past six years since he took on the responsibility for the development of the American Navy's Viking Rocket. This story is now fully told in the book, highly recommended to those experts in spacemanship who believe that a

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combination of suitable rocket fuels and a rocket motor will make a flight to the moon possible within the next few years. It will surprise them to read in detail the enormous technical problems which face any team engaged in rocket research. The very nature of this equipment demands completely automatic functioning of a host of different components, and if only one of them should be below full working capacity the whole project is inevitably doomed. Therefore checks, re-checks, and counter-checks must be applied first of all at the manufacturing stage, secondly during static-firing trials, and thirdly before the actual firing. This atmosphere Dr. Rosen has admirably succeeded in portraying in his book. If the story of the first ten Viking rockets fired by the American Navy proceeds sometimes haltingly and may occasionally read slightly repetitively, this is but an accurate portrayal of what must have occurred in reality.

The book contains relatively few precise scientific data, but is an admirable background to those books and articles in journals which deal with them fully. The Proving Station at White Sands and the American Naval Vessel *Norton Sound* come to life. These two names, famous throughout the world for rocket research, begin to mean more than just a dusty desert and the plan of a complicated ship. In years to come, when rocket flight may have become as commonplace to future designers as aircraft are to us today, will Dr. Rosen's book be compared to the Diary of Pepys? It may well be.

A. R. MICHAELIS

Nuclear Engineering

(*London, Temple Press, vol. I, No. 1, 3s. 6d.*)

There is undoubtedly a great thirst for knowledge of nuclear matters on the part of those whose work will soon be affected, such as power station engineers. The new journal, *Nuclear Engineering*, may well appeal strongly. Its first number is devoted mostly to engineering and organisation problems, with only a brief and very elementary article on the fundamental physics. The editorial does not give any indication of the policy of the paper; instead it gives a brief glimpse into the prospects and limitations of "Another Industrial Revolution". I am glad to see the question of export policy raised, since this is a subject on which this country still has to make up its mind. An article on the training of the nuclear engineer does not get very far with this important matter, since it is still in a very fluid stage. An article by Sir John Cockcroft describes the Harwell Reactor School. This provides only for 100 students per year, and the requirements are certainly far greater. Harwell will therefore probably become, as Sir John suggests, an advanced school, leaving the universities and technical colleges to do all the elementary training. There are a number of technical articles about reactors, with constructional details of the various Harwell reactors, including the zero energy fast neutron reactor, Zephyr, and a zero energy homogeneous reactor. There is a description of the two French thermal reactors, one an isotope-producing reactor similar to the Harwell Bepo, and the other a CO_2-cooled power-producing reactor somewhat similar to Calder Hall. Some details of the latter are given, for which corresponding information has not been reported in the case of Calder Hall. For instance, the weight of uranium (100 tonnes) and the canning material (magnesium) are stated. An article on the Dounreay fast reactor does not provide any basic information, but gives an idea of the cooling circuits. There are also articles on nuclear instrumentation and radio-isotopes. There is a brief news section and an abstract section for nuclear engineering publications.

My general impression is that the articles are too brief to give much significant information. This will no doubt be remedied in time. It might be a good idea to consider printing articles on selected topics in the form of instalments.

H. W. B. SKINNER

Outlook on Agriculture

Vol. I, No. 1, Spring, 1956.

This publication is to be somewhat of a companion to *Endeavour*. Like the latter it is published by Imperial Chemical Industries, and in general format it closely resembles it. In scope, it sets out to review some of the fundamental problems involved in agricultural science and to describe the most modern techniques that have been evolved for dealing with them. In a foreword to this first number Mr. S. W. Cheveley states the intent of ICI in producing this journal. It is proposed to cover as much technical and general knowledge as possible in the three fields of crop production, crop protection, and animal health. Initially, two issues will be published annually.

The first number of *Outlook on Agriculture* contains six papers compassing as many fields of agricultural research and ranging from the farmlands of Britain to the rice-fields of Japan. Each article is a useful summary of modern knowledge in its particular subject; most are tolerably detailed in their treatment, a minority being somewhat superficial. Where illustrations and tables are necessary, they are well executed. While the colour plate is most pleasing one cannot help feeling, however, that it serves no purpose other than embellishment.

In addition to the scientific articles, one page is devoted to book reviews and six pages to reports of scientific papers abstracted from world literature on crop protection, and animal health. Forty-two papers are briefly but adequately reported. This section will undoubtedly serve a very useful purpose.

The general impression gained from the first issue of *Outlook* is favourable and one looks forward to future numbers with pleasant anticipation, hoping that a standard similar to that achieved by its companion journal *Endeavour* will be aimed at. A somewhat more imaginative cover design would have been welcome but that is perhaps a minor defect in an otherwise worthy publication.

A. R. HILL

Brief Notes

The idea of a neuro-otological number of the *British Medical Bulletin* (May 1956, 15*s.*) originated with Dr. E. A. Carmichael, who acted as chairman of the planning committee. In 1944 the Medical Research Council formed their Otological Research Unit, out of which much excellent work has come. During the last quarter-century great changes have taken place in the explanations afforded for many auditory phenomena, and this issue of the *Bulletin* gathers together the most important researches on brain-ear relationships. It may be obtained from The British Council, 65 Davies Street, London, W.1.

Kodak Ltd. have produced a booklet, "Photography at Work", illustrated in colour and black-and-white, with a section on high-speed and time-lapse photography.

An interim list of 200 medical films is contained in the April issue of the *Scientific Film Review*, price 3*s.* 6*d.*

An "English-Esperanto Chemical Dictionary" will help those who find it easier to read *katalizilo* for catalyst, *kapsulo* (not to be confused with *kapsolo*, which is apparently an evaporating basin) for capsule, and so on. For 10*s.* it may be obtained from the following *adresu: Brita Esperantista Asocio*, 140 Holland Park Avenue, London, W. 11. *Anglujo.*

Sir Isaac Pitman & Sons publish a neat folding card entitled "Inorganic Qualitative Analysis: a Concise Scheme using the Semi-micro Technique", price 4*s.*

"Green's Lens Tissue Manual" giving instructions for lens cleaning is supplied free on request from J. Barcham Green Ltd., Maidstone, England.

DSIR has published a booklet on "Mass Spectrometer Researches" by G. P. Barnard, price 3*s.* 6*d.*, London, H.M.S.O.

Also from the Stationery Office may be obtained the Report and Accounts for 1954–5 of the Overseas Food Corporation, with chapters on cropping, livestock projects, and scientific and experimental work on soils, groundnuts, soya, maize, cotton, etc. The price is 6*s.* 6*d.*

Special report No. 62 of DSIR deals with "Dehydration of Fish", price 7*s.* 6*d.*, H.M.S.O.

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LETTERS TO THE EDITOR

"Luddites" of Atomic Power

Sir:

The editorial comment in the March issue of DISCOVERY says that the Central Electricity Authority might have better public relations; but you yourself seem already to be doing the job admirably. You talk smoothly of the "facts" about nuclear power without mentioning that the only facts of real importance are biological, and that we will be discovering them by personal experience in about half a century. Then the extents to which shielding and effluent control at power stations are adequate will become apparent. The early efforts made to get rid of radioactive rubbish suggest that the authorities have not realised that some of us are trying to live in this island and not just camp in it temporarily.

Power station costs are based on estimates of the precautions needed: our experience of industrial medicine shows that the dangers inherent in new processes are initially underrated: nuclear fission is the most revolutionary novelty yet undertaken: therefore it is probable that final costs will be much higher than those thought of now. Fortunately, a few of the papers given last summer at Geneva, notably those by people concerned with public health rather than commercial enterprise, showed the beginnings of alarm at fission-happy tendencies.

Perhaps nuclear energy will take care of the future and there may be no need to put further effort into rationalising coal-mining or trapping solar energy. But it would be unwise to assume this until, for example, we know how to keep the fish in the North Sea from becoming radioactive like those in the Columbia river. Also, why is leukaemia in children increasing so greatly? This may well be a consequence of the tentative toe we have been dipping into radioactivity during the last half-century.

In the meantime, if you are looking for an eponymous leader for those who remain sceptical in the face of nuclear optimism, Cassandra might be a more apposite choice than Ludd.

N. W. PIRIE.

Harpenden, Herts.

Use of Anti-Rodent Virus

Sir:

The article in your March issue, p. 115, by Mr. R. A. Davis on "Rats and Mice, their natural history and economic importance", makes interesting and instructive reading. It may be that, for space considerations, compression is unavoidable but where this leads to risk of misunderstanding it is most regrettable.

It is for this reason that I think it necessary to comment on the following statement by Mr. Davis in his reference to the use of cultures in rat and mouse control: "The type generally used in *S. enteritidis* var. *danysz, but var.* jena *has been used also. In 1947 four human cases due to the variety* jena, *were attributed to the use of 'virus' to control rodents*".

As a simple statement that is correct, but what has not been made clear is that although the attribution took place in 1947, it related to an occurrence in 1944.

Under Article 8 of the Infestation Order 1943 (S.R. & O. 1943, No. 680) and the Amending Order (S.R. & O. 1945, No. 847) the retail sale of the particular type of material for home mixing became illegal, as from Oct. 1, 1945, and has not since been resumed.

The appearance of this reference in the article by Mr. Davis caused me to look further into the following reference contained in paragraph 50 in the Report of the Working Party on Toxic Chemicals in Agriculture (H.M.S.O. 1953): "Nevertheless, we are informed by the Public Health Laboratory Service that the variety *jena*, which is generally considered to be more pathogenic to man, was isolated in 1949 from a sample of commercial rat poison".

That report was published after I had retired from Government Service and I endeavoured at the time without success to ascertain the grounds on which the particular statement was based. The appearance of this statement in a formal Government Report, and the use of it in the Report as an argument against the value of the assurances given by the trade in the course of the investigations by the Working Party that the strains used in bacterial rat poisons are of the *danysz* variety of *Salmonella enteritidis* (vide para 50 (i and iv)) raised it in order of importance much higher than the somewhat misleading statement in the article in DISCOVERY.

I have made inquiry of the Public Health Laboratory Service who have given me particulars of the occurrence, from which I have been enabled to get the facts and relevant correspondence from the parties concerned, with whom, by the way, I have no connexion.

The circumstances are quite different from those in the 1944 case quoted by Mr. Davis. In that case liquid virus had been sold retail for "home" mixing, and the presence of *jena* strain was merely an intensification although serious, of the risk arising from home handling and possession of bottles, full, partly full, and supposedly empty, a system made illegal from Oct. 1, 1945, as already stated.

That is in sharp contrast with what occurred in the case quoted in the Working Party's Report.

I have before me a letter dated Dec. 22, 1948, to the particular servicing company from the Local Medical Officer of Health wherein he expressed himself as glad to say that no obvious connexion was established between the "virus" organism and that isolated from the food-poisoning cases which had occurred some weeks previously. He went on to say that laboratory tests on a sample in an unopened ampoule of culture voluntarily supplied to him by the firm had revealed that in addition to the *danysz* strain, there was some evidence of the presence of *jena*. This led the firm to investigate the processing at the independent laboratories, where the fault in the particular batch of subculture was rectified. Under their purchasing arrangements there was provision for periodic testing to ensure that supplies were true to type. Shortly after this unfortunate experience the firm, who are of good repute, discontinued the use of bacterial cultures, *that is in 1949*.

As the firm were operating under a specific licence, the facts of this unfortunate and involuntary breach might well have been cleared up with the Ministry at the time by the Public Health Laboratory Service instead of being reserved for use years after the event and voluntary discontinuance by the firm of all "virus" practice, as ammunition to discredit reputable trade through the medium of the Report of the Working Party.

I am able to write with knowledge on this point by reason of my responsibility as Director of Infestation Control in the Ministries of Food and Agriculture from 1942 to 1952 when I retired from Government Service.

Yours faithfully,

W. MCAULEY GRACIE.

125 Pall Mall,
London, S.W.1.

Science Books for Children

Sir:

My fourteen-year-old son has an aptitude for mathematics and he seems to grasp scientific ideas easily. I have been trying to stimulate his interest by reading to him popular scientific books during the holidays. I would be very grateful for suggestions of suitable books for this purpose. I have quite a large library of works on Science, both popular and advanced, but so many of the popular books I have go too deep and assume too much in the way of elementary scientific education to be suitable for this purpose. It occurs to me that your readers may include many other fathers who have the same problem and who may have suggestions.

ROGER NORTH.

Rougham Hall,
King's Lynn, Norfolk.

The Supply of Scientists

Sir:

Your April editorial, "Has the Penny really Dropped?" calls for a more "scientific" approach to the problem of increasing the supply of scientists and technicians. Agreed that some of Sir David Eccles's new-found £97 million should be spent on fundamental research into the problem, this still

leaves us without any immediate remedy. It will take even longer to train more science teachers for schools, and for their influence to be felt at tertiary educational levels.

The solution lies in the exploitation of the rapid learning power, enthusiasm, and ambition of all reasonably intelligent sixteen–eighteen-year-olds. It is to this group we must look for help. Their way into a scientific career must be made clear, direct, and well-subsidised. Basic chemical, physical, and mathematical concepts learned with such effort and tedium at the age of twelve and thirteen can be assimilated with extraordinary rapidity by keen young people who know that in a few months they will be applying these principles to specific scientific ends.

Let the technical colleges—those already in existence and those to be built with Sir David's money—take over scientific education and training, and leave the schools to achieve their primary functions of supplying physically fit, literate, and even cultured young people who will look on their one or two years' high-pressure technical course as a new and exciting adventure.

Yours faithfully,
TEACHER, MIDDLESEX.

Sir:

Your editorial, "Has the Penny Really Dropped", applied a goad where it is still clearly needed; the ox is moving, but too slowly to bear comparison with the streamlined vehicles which may represent scientific education in the U.S.A. and the U.S.S.R.

Part of the trouble is the general attitude of our society to the scientist. We still find grammar schools trying to persuade their pupils to adopt an academic course in preference to a scientific one. You yourself refer to "technological education"—reflecting a similar view—that science is a subject for mechanicians, a view that has been hotly contested in your own pages.

Science in education has been forced into the curriculum by necessity, it has not been welcomed as it should have been. Partly the fault lies with the universities and their methods of selection. It is here that the problem needs to be attacked. Universities must accord the same status to the scientist as to the academician. This would ensure that grammar schools guide pupils into whichever branch most suits their aptitude, not, as at present, into the course which brings the school most academic honours.

J. D. CHAMBERS.
4 The Mount Square, London, N.W.3.

NEW SCIENTIFIC INSTRUMENTS

This feature is designed to provide information about new scientific instruments which have come on the market. The detailed facts in it are the responsibility of the manufacturers, being taken from literature supplied by the makers. The editor will welcome information from manufacturers about new scientific instruments they are putting on the market. As these notes are intended for the large section of our readership composed of professional scientists, etc., we depart from our customary practice and use symbols and abbreviations to the full in order to be able to convey the maximum amount of detailed information.

Bone and Artery Drier

The BA2 unit has been designed for research into the technique of vacuum drying of bone and arteries in tube containers for subsequent grafting into living tissue. Two different methods of drying are commonly employed (*a*) the tissue is devitalised but the protein far from denatured, by regulating the drying conditions so that the temperature of the tissue comes into equilibrium with that of the room during the drying process, and (*b*) the tissue is devitalised as little as possible, by being maintained at some pre-determined sub-zero temperature throughout. The unit is arranged so that the vacuum chamber may be connected to the vacuum system in different ways according to which of these methods is to be used.

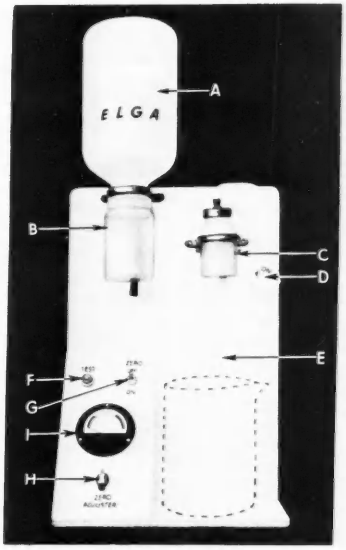
The vacuum system includes a "Speedivac" Model 2SC20 two-stage rotary vacuum pump connected to the drying chamber with appropriate control valves and demountable unions. The vacuum chamber (24 in. long by 6 in. diameter) will accommodate up to 10 glass artery drying tubes, 5 of $1\frac{1}{4}$ in. and 5 of $\frac{5}{8}$ in. diameter. The refrigerating system consists of a hermetically sealed condensing unit which cools an insulated tank divided into two compartments which can either contain refrigerating liquid for rapidly freezing specimens, or be used empty as a refrigerated store.

Edwards High Vacuum Ltd., Manor Royal, Crawley, Sussex.

Portable Deioniser

The Elgastat self-contained portable deioniser (see fig.) yields instantaneous water at the rate of up to $15\frac{1}{2}$ l./h at the inlet temperature. The crude water is poured into the storage tank A, then passed through a cartridge B containing strong mixed ion exchange resins (Elgalites), where the dissolved salts are removed; the cations and anions are exchanged for hydrogen and hydroxyl ions respectively which instantaneously re-form into water molecules. Thus purified, water is drawn from the outlet E by opening the flow control valve D.

A built-in conductivity meter I, calibrated in Ω/cm, is provided for testing the purity of the effluent. This, it is claimed, complies with the British Pharmacopoeia and is equal to triple glass distilled water.



Elgastat portable deionizer.

When the Egalites are exhausted the cartridge B is exchanged for a new one in a few seconds. One cartridge will deionise about 850 l. of soft or 36 l. of hard water.

Elga Products Ltd., Elga Works, London, S.W.19.

Combined Intensity and Total Rainfall Recorder

This instrument, designed by the Road Research Laboratory of the Department of Scientific and Industrial Research (*Quart. J. R. Met. Soc.*, 1955, vol. 81, p. 449) comprises two units: one to record the rate of rainfall and the other

the total rainfall. It can also be adapted to the measurement of small rates of flow of non-corrosive liquids.

In one unit a continuous weighing is made of the quantity of rain collected in a few seconds, and this provides a measure of the "instantaneous" rate of rainfall. The other unit is similar to a standard Meteorological Office total rainfall recorder.

The rain is collected in a funnel and led into a cylinder suspended from a counterweighted balance arm to which a recording pen is also fixed. When equilibrium is established between the inflow into this cylinder and the outflow through a sharp orifice and tapered needle device at the bottom, the rate of rainfall is indicated on the chart. A second pen actuated by a rising float in the float chamber into which the rain empties itself, indicates the total rainfall.

The recording unit includes either a synchronous or clockwork motor with a range of speeds of the chart varying from 0·5–12 in/h. If set at 6 in/h. renewals will not be necessary for eight days. Provision is also made in the electrical model to prevent freezing during cold weather.

Teasell & Bowey (Inc.) Ltd., 75/9 Hagley Road, Halesowen, Worcs.

Wide-range super moisture meter.

Wide Range Moisture Meter

The Shaw "wide range super" moisture meter (see fig.) is a direct reading instrument. It utilises the fact that while the dielectric constant of most substances, particularly organic materials is between 3 and 5, that of water is 80 and the increase of capacitance due to the water is much greater than that due to the sample. The range is from complete dryness to maximum moisture content of the material and measurements are made on samples of 10–50 gm. in precision sample containers at 150 Mc/s. for a mains consumption of 20W at 200–250V 50 c/s. stabilised. The makers state that the meter readings are unaffected by parameters other than dielectric constant such as hysteresis, power loss, pH differences, dyeware, or wetting agents.

Shaw Electronics, 31 Market Street, Bradford, Yorkshire.

Sealed Micro-switch

Micro-switch type CRNL2 built for use in difficult conditions is sealed against moisture dust and oil. It is a single pole double throw snap action switch of approximate dimensions 82×110×25 mm. with an electrical rating of 3A at 460, 5A at 250, and 10A at 25V a.c. It is a development of type CRNL and is supplied in both left and right hand versions. The drop forged actuating cam is adjustable through 70° and the roller is case hardened to withstand rough use. The switch may be operated by cams, star-wheels, sliding rods, moving carriages, etc., the force required is 24 oz. wt.

Burgess Products Co. Ltd., Dukes Way, Team Valley, Gateshead.

FAR AND NEAR

Scientists in Birthday Honours

Science was well represented in the Birthday Honours announced on May 31. Lord Cherwell, C.H., lately Professor of Experimental Philosophy at Oxford became the only new viscount. Two of the three new baronies were for services connected with science: Sir Henry Cohen received a barony for services to medicine (already in May he had been in the news for an outspoken statement on the threat to smokers of lung-cancer). The other baron, Sir Ronald Moce Weeks, besides being chairman of the National Advisory Council for Education in Industry and Commerce, is President of the British Scientific Instruments Research Association.

New Chairman of Advisory Council, DSIR

Sir Hugh Beaver has decided to resign from the chairmanship of the Advisory Council of the Department of Scientific and Industrial Research, and Sir Harry Jephcott will take his place. Sir Hugh Beaver will continue to serve as a member of the Council.

New Director of Science Museum

Mr. T. C. S. Morrison-Scott has been appointed Director of the Science Museum, South Kensington, in succession to the late Dr. F. Sherwood Taylor. Mr. Morrison-Scott, who is aged 47, is at present a Principal Scientific Officer at the Natural History Museum.

The Night Sky in July

The Moon.—New moon occurs on July 8d 04h 37m, U.T., and full moon on July 22d 21h 29m. The following conjunctions with the moon take place:

July			
6d 17h	Venus in conjunction with the moon	Venus	3°S.
7d 05h	Mercury	Mercury	2°N.
11d 07h	Jupiter	Jupiter	7°N.
17d 15h	Saturn	Saturn	3°N.
27d 14h	Mars	Mars	11°S.

In addition to these conjunctions with the moon, Jupiter is in conjunction with Regulus on July 2d 09h, Jupiter being 0°.6N., and Mercury is in conjunction with Regulus on July 3d 20h, Mercury 3°.3N. Also, on July 3d 20h Mercury is in conjunction with Venus, Mercury 3°.3N.

The Planets.—Mercury rises at 2h 40m, 3h 30m, and 4h 45m, on July 1, 15, and 31 respectively, but will not be easy to observe as it is close to the sun. *Venus* rises at 3h 20m, 2h 20m, and 1h 40m, at the beginning, middle, and end of the month respectively. It is interesting to notice the close approach of the bright star Regulus, Jupiter, Venus, and Mercury—though the latter may not be easy to detect—on July 3. *Mars* rises at 23h 20m, 22h 40m, and 21h 50m, on July 1, 15, and 31 respectively, and is visible during the later portion of the nights and the morning hours before twilight, but it lies too low in the constellation Aquarius, in which it has an eastward movement, for good observation. *Jupiter* sets a little more than two hours after sunset at the beginning of July and draws closer to the sun later on, setting less than an hour after sunset on July 31; its close approach to Regulus on July 2 has been referred to. *Saturn* is visible after sunset but lies low in the constellation Libra and towards the end of the month is south of γ Librae. Its close approach to the moon on July 27d 15h, that is, at 3 p.m. on July 27, has been pointed out, but as the moon's revolution round the earth separates its angular distance from Saturn by about 1° in two hours, it will be some distance from it at the time of observation.

On July 5d 01h the earth is at aphelion, that is, at its greatest distance from the sun, or nearly 94½ million miles. This corresponds closely with the longest days in the northern hemisphere which take place about a fortnight earlier; as most readers are aware, there is very little correlation between the distance of the earth from the sun and the climatic conditions at any place, so that the greatest distance of the

earth from the sun corresponding nearly in time with mid-winter in the southern hemisphere is not a case of cause and effect.

New Shell Offices

A model of the new main offices in London of the Royal Dutch/Shell Group of oil companies is on view at the Summer Exhibition of the Royal Academy.

The basic idea is a development benefiting Londoners and visitors to London. The presence of the National Theatre, the Festival Hall, a smaller concert hall and a riverside hotel, guarantees that the area will not run the risk of commercial development areas, having an intense daytime life, but deserted after office hours. This mixed development on the South Bank site is the first practical example of an interesting and novel conception of heightening the interest and beauty of London by night as well as by day.

The Shell offices have been designed by Sir Howard Robertson, A.R.A., a past president of the Royal Institute of British Architects. The "Upstream" block is to be built on three sides of a square with the open side facing the Thames. Consisting of eleven storeys and rising to a height of over 150 feet, it will be dominated by a twenty-six-storey tower, over 330 feet high. The "Downstream" block will comprise an "L"-shaped, eleven-storey building abutting another of only three storeys, fronting on to Belvedere Road.

Aboriginal Rites Films

The Australian Film Bureau in Canberra is to receive a collection of films showing some of the most secret and ancient rites of Australian aborigines. These ceremonies are reported to have been seen by only three white men. The Bureau will reserve the films for screening to special audiences in Australia and overseas. The recording of sound tracks for the films will be supervised by Mr. C. Strehlow, a member of the Anthropology Research Board of Adelaide University.

Mr. Strehlow said on May 14 that the films depicted aboriginal ceremonies based on sacred myths, and portrayed in a series of acts known as a ceremony cycle. Carried out in utmost secrecy by the Arunta, Kukajta, and Matuntara tribes, the ceremonies had never been filmed before, and the full cycle had been seen only by himself and the explorers Spence and Gillan. Mr. Strehlow said he had been allowed to take the films only after giving an assurance that they would never be shown commercially or to any aborigine.

New Scientific Film:
"The Titanium Pigment Story"

16 and 35 mm. Colour. 23 min. Made by: Film Producers Guild, London. Available from: British Titan Products Ltd., York.

This film sets out to advertise the superiority of titanium oxide as a pigment. In this aim it succeeds admirably. The colour photography is excellent, the script is tight and rapidly moving, and the spoken commentary flows in a continuous uninterrupted stream. The major part of the film is devoted to demonstrating the many scientific tests applied to the pigment, during and after manufacture. Tests range from simple visual inspection to spectrographic analysis, from painting-out to electron microscopy, and a non-scientific audience might well be more bewildered than convinced at the end of it. In all these scientific controls it seemed amazing that the temperature of the giant kilns was adjusted by a simple workman merely tapping the

Aerial view of the South Bank Development Scheme. (*A Shell photo.*)

valve which regulated the flow of gas to the furnace; surely automatic control would be more sensitive and more accurate. It is perhaps a pity that its very success as an advertising film may restrict its circulation in technical colleges, universities and schools; on the other hand the sales staff of British Titan Products should be grateful to the Film Producers' Guild for having added to their palettes such a brilliant pigment.

Decca CI

The exhibit by Decca Radar Ltd. at the recent Physical Exhibition is an electronic computer built on entirely new principles. Known as Decca CI, the computer employs a new component, technically called a ferrite cored inductor. Decca CI is the first core-operated computer in the world and places Great Britain in the forefront of present-day electronic data processing development.

In Decca CI the magnetic cores are used to perform not only storage functions, but also arithmetical operations. Hitherto, computers of similar characteristics to Decca CI have used either thermionic or gas-filled valves for these arithmetical circuits. The cores used in the CI are ring-shaped and are only two millimetres in diameter; connexions are made by the latest printed circuit techniques. The power required to operate the cores is very low and is provided by a small number of thermionic pulse generators.

Decca CI is a high-speed serial digital computer intended primarily for computation on scientific problems. Input information is fed to the machine by punched tape prepared on a teleprinter which simultaneously prepares a copy in plain language. Programme input is in the form of words, each of 40 binary digits. Each word specifies two operations and includes the address of the next instruction. For arithmetic operations a decimal notation is adopted and a word then consists of a digit indicating the sign followed by a nine-decimal digit word.

Information within the computer can be stored either on a 63-channel magnetic drum or in magnetic core shift registers when quick access is required. A novel technique is used in the magnetic drum store on which the digit rate is three times that of the computer itself. The access time to the drum is thus one-third of what it would be if the drum rotated at a speed appropriate to a 1:1 digit rate.

It is claimed that the use of these new techniques and components leads to an improvement in stability and reliability, and a lowering of power consumption and heat output.

A Banner with a Strange Device

A new banner (target) streaming device, known as Excelsior, has been developed for the Royal Navy, and has been cleared for use in Sea Hawk F.G.A. Mk. 4 aircraft.

The conventional method of banner-towing is to lay a banner out on a runway and tow it off with a Meteor 7 aircraft. Due to interference with other flying operations caused at busy air stations by the employment of this method, towing aircraft often have to operate from other airfields and rendezvous with Squadrons based on the major air stations. This method has important disadvantages; sometimes when all aircraft arrive over the range, weather is unsuitable; at other times, due to last-minute unserviceability or a blocked runway, firing aircraft may be delayed in joining the target aircraft and the latter may run out of fuel and return to base before practice can take place.

Excelsior removes these disadvantages. It enables a banner to be towed in a Squadron aircraft taking off at the same time and from the same airfield as firing aircraft, the banner being paid out while in the air. The heart of Excelsior, in the development stage, was a fluid fly-wheel as fitted to a 1937 10 h.p. motor-car which was bought from a scrap yard for £4 10*s*. 0*d*. A drum carries the towing wire and a slip mechanism operated by a bomb release unit enables the banner to be released at any time.

Excelsior will make it possible to carry out target practice at higher speeds and greater altitudes than formerly. It will also, for the first time, enable Squardons embarked in aircraft carriers operating beyond the range of shore-based "tugs" to practise firing in any suitable weather conditions in any part of the oceans.

Louis Rapkine Association

The British Section of the Louis Rapkine Association was inaugurated on Monday, May 14, at the Ciba Foundation, 41 Portland Place, W.1, when Dr. Etienne Berthet, Director of the International Children's Centre, gave an address on "Evolution et Tendances de la Médecine Contemporaine". This Anglo-French Association of doctors and research workers in the biological sciences, who have held scholarships to enable them to study recent developments in their special subject in Great Britain and France, has been founded in memory of the distinguished French biochemist, Louis Rapkine. A man of exceptional personal qualities, he believed in the need for international co-operation in science and devoted much of his short life (he died of cancer in 1948 at the age of 44) to this cause.

Americans' Man-Made Diamonds

Man-made industrial diamonds are now being produced in limited quantities at the Detroit pilot plant of General Electric. Last month the firm presented a cluster of the diamonds to the Smithsonian Institution, Washington, at a special ceremony. This "laboratory achievement" may make an important impact on American industry and defence, it was then suggested.

Mr. J. S. Gillespie, the manager of the firm's diamond project, said: "Home-grown diamonds will give the U.S. an independent source of a vital commodity. Industrial diamonds could become a $200-million-a-year business within the next decade, if the cost of man-made diamonds can be brought down below the cost of those now being mined."

At present the United States imports 90% of the world's output of diamonds for which she pays $50 million

A hundred carats of man-made diamonds.

annually. A speaker made the point that the speed and efficiency of grinding and cutting operations, basic to a large section of industry, is "a multiplier that exerts great leverage on the American economy". This becomes increasingly important as industrial technology tends towards ever stronger and harder materials in support of demand for higher temperature, higher speed, higher stress, and higher mechanical performance.

Electron Accelerator

The Massachusetts Institute of Technology and Harvard University will jointly design, build, and operate in Cambridge a six-billion-volt electron synchrotron, to be called the Cambridge Electron Accelerator. It will be devoted to basic research in the structure of matter. Its purpose is to push back the frontiers of man's knowledge of the particles within the nucleus of the atom. The new "atom smasher" will cost about $6·5 million; the funds will be provided by the U.S. Atomic Energy Commission. Work on the detailed plans will begin immediately, and the machine will be completed in about four years. Dr. M. Stanley Livingston, Professor of Physics at the Massachusetts Institute of Technology, will be the first director.

Earth-moving Giants for U.K.

Britain is to import from Australia six giant machines for use in winning coal from open-cast mining. The machines are being made by the Le Tourneau-Westinghouse Company in Sydney. They can carry 20 tons of rock and earth at up to 30 miles an hour. They are used mainly in levelling ground for aerodrome construction and for stripping the faces of open-cast mines.

Plotting the World's Pastures

FAO is drawing up a new vegetation map of the world. It will take some years to complete. It will contribute to the world survey of resources which FAO is soon to undertake. It will also enable certain useful comparisons to be made; for instance, if one type of grass is successful in an area where certain conditions apply, a glance at the map will show where else the same grass species may be worth planting. The map will also be a step towards the standardisation of vegetation nomenclature and classification.

A start will be made with two areas, the Near East and Africa. FAO is itself undertaking the mapping of the Near East, on which very little work has previously been done. It has already been found that there is not so much true "desert" as was once supposed; large areas on the fringes are proving to be "steppe", a more hopeful proposition altogether.

H. L. Shantz, an American, made a vegetation map of Africa in 1923: this will be the basis of FAO's African section of the world map. The Organisation hopes that others, who may have made maps of particular regions will collaborate by placing their knowledge at the disposal of FAO (Food and Agricultural Organisation of United Nations, Rome).

"Dip. Tech. (Eng.)" and "Dip. Tech."

The National Council recently set up under the chairmanship of Lord Hives has now announced the details of the new technological awards. It will be equivalent to a British university honours degree and cannot be gained with less than three years' full-time study plus a year in industry. It is to be called "Dip. Tech. (Eng.)" for engineers and "Dip. Tech." for other technologists. The qualifying age will normally be eighteen, and colleges seeking recognition for a "Dip. Tech." course must make formal application to the Council.

An Educational Correspondent comments: if the selected technical colleges can achieve all the requirements set out in the announcement, all well and good. That is to say, a course consisting of advanced work in technology, plus liberal studies, plus not less than one year's actual industrial experience, is to be welcomed. The courses are to be residential; the staff is to be highly qualified and engaged on research besides their teaching activities. The colleges are to specialise in advanced studies, and the intake of students will be varied. The scheme is obviously good planning. If it fails to come up to its standard then one could point out that the universities *are* already running something similar but only on a very limited scale.

It is interesting that an attempt is being made to set up something of university standard and in university style entirely independent of the universities. One wonders why. Is it that the universities would look askance at courses so grafted on to industry—or that industry does not trust the universities to keep practical needs sufficiently in mind?

Greenland to Grow Inca Corn?

The well-known Peruvian author, Dr. Haya de la Torre, after a recent visit to Greenland, suggested that tests should be made with the growing of the Inca cereal *quinoa*. This is a native of the Andes which has proved to be viable in Arctic regions. *Quinoa* has a high nutritive value.

Catching Atoms with the Navy

The Nore command of the Royal Navy has arranged a lively programme for their three open days at Chatham over August Bank Holiday. A "slightly radioactive" 40-foot model of a frigate normally used for training officers will enable the public for the first time to try its hand at "hunting atoms" with a Geiger counter. The model contains an old motor-boat engine from Monte Bello which has emitted a stream of radioactivity since the last-but-one British atomic tests in the Pacific. The amount of radioactivity is of course not dangerous.

This is only one of the many exhibits at this year's Navy Days; there will be the usual elaborately organised display in the main dockyard basin which simulates operational conditions during a naval engagement in modern "triphibious" warfare. The display will include the remarkable spectacle of a rescue by helicopter with Lt.-Cdr. Sproule's recently developed scoop-net. Proceeds at Navy Days go to charity.

Rangoon Technological Institute

A report from Moscow announces that Soviet experts have left for Burma to discuss the plans for the Rangoon technological institute that is to be built at the Russians' expense. Materials and equipment for the institute are also being supplied by the Soviet Union.

The institute will have hostel accommodation for its entire student body of 1000.

"Apart from an auditorium, laboratories, workshops and other educational premises, the plan includes a library for 100,000 books, dining-rooms, a medical centre, sports grounds and a swimming pool," reads the report.

Charting Thunderstorms

The World Meteorological Organisation (WMO) has completed its three-year project of charting the course of thunderstorms over the world and is now preparing to present the data collected in a series of seventeen world maps. The maps will give the average number of thunderstorm days for each month, for the quarters and for the entire year. The thunderstorm mapping began at the request of another United Nations agency—the International Telecommunications Union.

Hungary's First Atomic Reactor

The building of Hungary's first atomic reactor began in April, on "Liberty Hill" outside Budapest, says a report from Hungary. It is centred on the experimental atomic pile given by the Soviet Union, and Soviet technicians will begin fitting reactor equipment next spring. The reactor is for use in industrial, scientific, and medical research.

Plastic Silo Bags

Giant plastic bags, or tents, each with a capacity of hundreds of tons, may provide U.S. farmers with an inexpensive solution to one of their major storage problems. Rutgers University reports favourable and encouraging results with livestock feed covered with plastic. The plastic tents are not expected to replace the standard silos, but may prove to be just what the farmer needs for keeping a reserve food supply for his stock.

It is pointed out that the ordinary silo is expensive because it must be

built to avoid leakage and to withstand the gas pressures that are generated in the preservation process. On the other hand, plastic silos, which are comparatively cheap, are particularly valuable because of their gas-tight characteristics. These keep the bags relatively free of oxygen so that mould is prevented from forming and caratene and protein are retained. The plastic bags can be used anywhere on the farm.

Great Advance—Down One Road

John Laing and Son Ltd., civil engineers and contractors, have evolved a concrete spreader for laying a 24-foot-wide roadway in one operation. Recently the Parliamentary Secretary to the Ministry of Transport opened a short link-road in Nottinghamshire, the Oxton by-pass, which had been laid by airfield runway plant.

Commenting on the Laing road-laying technique, the Federation of Civil Engineering Contractors has said that a great advance has been achieved which opens the way to a system of concrete roads that could revolutionise British motor travel.

Dam Threatens Ancient Monuments

UNESCO is co-operating with the Egyptian Government in the compilation of a complete survey of ancient monuments which may be covered by water when the proposed new Aswan dam is built. Prof. J. Cerny, the distinguished Egyptologist, of Queen's College, Oxford, has joined experts from Italy and America who have started exploratory research in the area of Abou Simbel. Further archaeological expeditions are planned for this year to ensure that a complete study, including photographic recordings of the monuments and the evidence they offer of the art and civilisation of ancient Egypt, can be made before it is too late.

British Research Develops Novel Tractor

An hydraulic tractor has been developed by the National Institute of Agricultural Engineering at Silsoe, Bedfordshire. Its hydrostatic transmission (only made possible by the introduction of synthetic rubber) makes it of great potential value for earth-moving machinery also.

ERRATUM

In the note on an "Electronic Watch", May DISCOVERY, p. 180, the coil should have been described as being wound with 40 metres of wire (not 40 millimetres), comprising 10,000 turns.

Late Classified Advertisement

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Graduate Electronic Engineers interested in Digital Computers are also invited to apply.

This is a real opportunity to enter an expanding field of research work in modern laboratories and interested applicants should write with full details to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1813A.

A newly issued list, No. 4, containing 72 pages of Eastman Organic Chemicals, has been sent to our regular customers. If you would like to have a copy of this publication, 'phone or write us. There is probably at least one item in the list which you can use and so save the time and money involved in synthesising it yourself.

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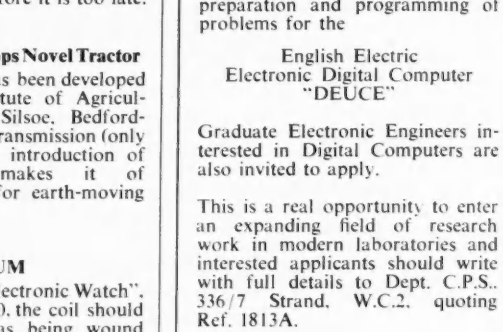

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Classified Advertisements

OFFICIAL APPOINTMENTS

METALLURGISTS required by THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE. The duties, which are administrative as well as technological, will include the melting, casting, and working of radio-active metals and alloys in development and production. The successful candidate may be required to undertake shift work. Candidates should possess A.I.M. or exempting qualifications such as an Honours Degree in metallurgy with appropriate experience in a factory or laboratory.

Salary: £766 at age 25 to £1050 at age 34 or over on entry, rising to £1199 p.a. Contributory Superannuation Scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates. Alternatively assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to Senior Recruitment Officer at the above address not later than July 6, 1956. Please quote ref. 1189/47.

MINISTRY OF LABOUR AND NATIONAL SERVICE: H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts. Age at least 21 and (unless exceptionally well qualified) under 30 on June 1 in the year of application with extension for regular service in H.M. Forces. London salary (including extra duty allowance where payable) £533 (at age 21), then according to age up to £708 at 26 or over, rising to £969. Somewhat lower outside London. A special increment of £25, within the scale, is granted after passing probation. Higher posts filled by promotion from Class II.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health, and welfare of work-people and extend to all manufacturing industries and to certain other places, including docks, works of engineering construction, and building operations.

Candidates must normally be university graduates, preferably in Engineering or Natural Science (or comparable technical qualification, e.g. A.M.I. Mech.E.). Graduates in other subjects, including Arts, are eligible. Works or other practical experience an advantage. Candidates without degrees (or comparable technical qualifications) who have good general or technical qualifications, and have had considerable works or other practical experience (especially in responsible positions) will also be considered. Pay and conditions of service are under review.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280/12.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, Berks., for research and development work on the deposition of metallic coatings by vapour phase methods. The minimum qualification is H.S.C. (Science) or equivalent. Candidates for the post of Experimental Officer, who must be at least 26 years of age, should preferably hold a pass degree.

Experience in one or more of the following would be an advantage:

Vacuum evaporation or cathode spluttering of metals; any metal deposition process; vacuum technology; gas pressure and flow measurement.

Candidates should have aptitude for designing and constructing equipment and a genuine interest in and capability for applied research.

Salary. Experimental Officer: £846–£1040 p.a.

Assistant Experimental Officer: £353 at age 18 to £460 at age 25 or over on entry, rising to £756 p.a.

At present the rates for women over the age of 21 are slightly lower.

Contributory Superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates or alternatively, assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to the Senior Recruitment Officer at the above address not later than July 11, 1956. Please quote ref. 1184/47.

Applications are invited for pensionable posts as

EXAMINERS

in the

PATENT OFFICE

to undertake the official scientific technical and legal work in connexion with Patent Applications. There is a small number of similar posts in the Ministry of Supply. Recruitment is by competitive interview; the Selection Board will sit at frequent intervals.

Candidates must be between 21 and 28 years of age during 1956 (up to 31 for permanent members of the Experimental Officer Class) and have first- or second-class Honours degree in physics, chemistry, mechanical or electrical engineering, or mathematics. Candidates taking their degrees in 1956 may apply before the result of their degree examination is known.

Emoluments in London including Extra Duty Allowance for 45½-hour week on the scale £582 to £1414 (men). Starting salary assessed according to periods of National Service and post-graduate experience, rising after 2 years' service to £751 (men) at age 24 or over. After 5 years' Patent Office service (3 or 4 years in exceptional cases) advance in scale to £1099 (men). Good prospects of promotion to Senior Examiner £1414 to £1800 (men) with later opportunities of promotion to Principal Examiner and to some still higher posts. Women's salaries above £582 somewhat lower than men's but subject to annual upward adjustment under Equal Pay Scheme. Pay and conditions of service are under review.

Application forms and further information from the Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting number S 128/56.

UNIVERSITY COLLEGE OF THE GOLD COAST

Applications are invited from candidates with a degree or equivalent qualification in Chemistry and at least two years' subsequent experience, for appointment as Soil Analyst. Salary Scale £850×40–£1570 p.a. Allowance £100 p.a. per child (max. £500 p.a.). Outfit allowance £60, FSSU. Passages for appointee, wife and maximum of five children, on appointment, normal termination and leave. Part-furnished accommodation at rent not exceeding 7·5% of salary.

Detailed applications (six copies) naming three referees by July 13, 1956, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

PHYSICIST or PHYSICAL METALLURGIST required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, Berks., in the grade of PRINCIPAL SCIENTIFIC OFFICER to lead a section carrying out basic and applied research into radio-active metals and alloys.

Applicants should have a first- or second-class Honours degree in physics or metallurgy with appropriate research experience. They should have a wide knowledge of physical metallurgy with emphasis on alloying and mechanical properties. Experience in handling

radio-active materials would be an advantage.

Salary will be assessed according to age, qualifications and experience within the scale £1339–£1771 p.a.

Contributory Superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates or alternatively assistance towards legal expenses incurred in house purchase may be available.

Requests for application forms by POSTCARD to the Senior Recruitment Officer at the above address not later than July 6, 1956. Please quote ref. 1180/47.

PHYSICISTS req'd for MIN. OF SUPPLY RESEARCH AND DEVELOPMENT ESTABS. in South Mids. and South of England. Work directed towards solution of problems and development of new ideas in fields of radio communications, radar, guided missiles, aircraft and aircraft equipment, gas turbines, instrumentation, etc. Candidates should have or be obtaining 1st or 2nd class hons. degree or equiv. Post-graduate research and special experience in any of above fields an advantage. Appointments in Scientific Officer grade (min. age 21) at salary according to age, experience, etc., in range £514–£933 (Superannuable). Forms from MLNS, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 214/6A.

METALLURGISTS required by Ministry of Supply, London Headquarters, for general liaison work connected with metallurgical research and development projects in Government Establishments, necessitating knowledge of metallurgical research and development activities in this and other countries. Quals.: Higher School Certificate (Science) or equivalent, but possession of a pass degree, H.N.C. or A.I.M., an advantage. Appointments according to age, experience, etc., as Experimental Officer (min. age 26). Salary within range £838–£1008. Forms from MLNS, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.403/6A. Closing date July 20, 1956.

MATHEMATICIANS required at various MIN. OF SUPPLY Experimental Establishments for work in numerous fields of interest including Aerodynamic and Structural problems arising in Supersonic flight; application of mathematical techniques to control and heat transfer problems of Guided Missiles; Radio propagation; application of high-speed computing techniques to fluid dynamics and solid mechanics, etc. Candidates should have, or be obtaining, a first- or second-class Hons. degree. Post-graduate research or special experience in any of above fields would be an advantage. Appointment according to age, quals., etc., as SCIENTIFIC OFFICER (min. age 21) on salary range £539–£973 (London), £514–£933 (Provinces) (Superannuable). Forms from MLNS Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 198/6A. Closing date July 14, 1956.

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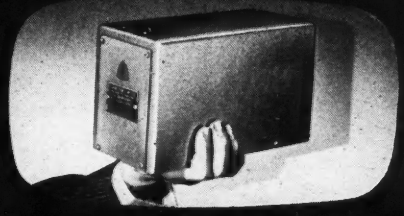

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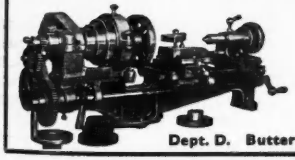

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